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SUPERCONDUCTOR DEVELOPMENT REPORTED

High Current Density Superconductor

OW260425 Tokyo KYODO in English 0358 GMT 26 May 87

[Text] Tokyo, 26 May (KYODO)--Kawasaki Steel Corp has developed a superconducting ceramic made of yttrium barium copper oxide that has a current density of 410 amperes per square centimeter, a Kawasaki Steel spokesman said Tuesday.

The new ceramic material, which loses all its electrical resistance at 93 kelvin, or minus 180 c, is a single phase material containing no materials that block the conduction of electricity, the spokesman said.

Kawasaki Steel has also succeeded in processing its new yttrium barium copper oxide ceramic material into 10 meter-long wires with a diameter of 1 millimeter.

The company said the test manufacture of the ceramic material shows it is possible to produce it with a high degree of homegeneity on an industrial scale.

Superconductor Ceramics Film

OW011035 Tokyo KYODO in English 1017 GMT 1 Jun 87

[Text] Osaka, 1 Jun (KYODO)--Sumitomo Electric Industries, Ltd., Japan's largest electric wire and cable maker, said Monday it has developed a thin ceramic superconductor film which offers no electrical resistance at minus 188 degree C or 85 kelvin.

The new product, a yttrium-barium-copper oxide is 0.1-1 micron thin film, shaped 2 centimeters long and 3 centimeters wide.

It has a current density of 32,000 amperes per square meter at a temperature of liquid nitrogen, minus 196 degrees C, or 77 degrees kelvin, which is viewed as a condition for practical use, Sumitomo said.

The Osaka-based firm said the thin film will be of practical use for super-speed memory devices, since it can send 10 times the normal electric current at a temperature of liquid nitrogen.

/9274
CSO: 4307/521

DEVELOPMENTS IN ELECTRONICS CERAMICS REPORTED

Tokyo NIKKO MATERIALS in Japanese Jan 87 pp 26-29

[Article by Hirotoshi Shibata]

[Text] Ceramics, which are used in various solid devices, have performed an important part in the development of the electronics industry. The development of these devices known generically as electronic ceramics can be said to be the basis for the development of the electronics industry even at the present; its importance, therefore, has become even greater. Recently, Toyo Soda Mfg. Co., Ltd. and Assistant Professor Kenji Uchino at Jochi University have succeeded in jointly developing an epochmaking piezoelectric actuator, one of the electronic ceramics. This is an actuator which develops a "bending phenomenon," though it consists of one ceramic sheet, and is said to have merits in terms of price and quality, compared with the existing actuators. It is not an exaggeration to say that it is one of the electronic ceramics attracting a great deal of public attention. In this article mention will be made of the present condition of electronic ceramics, centering on the piezoelectric actuators.

Already Adopted Widely

Ceramics that generates electric pressure when pressure is applied (a piezoelectric effect) or develops a deforming phenomenon when electric pressure is applied (a reverse piezoelectric effect), is called piezoelectric ceramics. This uses ferroelectric ceramics such as barium titanate and lead zircotitanate (PZT) and has already been adopted in a broad area. It is applied, for instance, to a piezo-vibrator, compound vibrator, wave filter, the vibrator for a piezoelectric transducer, etc. and the transformer for an ultrasonic wave-applied measuring instrument, microphone, sonar and defectoscope. Additionally, what go unnoticed in daily life are not items such as an igniting element for portable cooking gas stoves and cigarette lighters, and a switch for electric blankets and foot warmers.

Originally, piezoelectric ceramics has the following characteristics: 1) The magnetic field is small. 2) It is possible to make it compact. 3) Its electric power consumption is low. The application of piezoelectric ceramics has made progress in these characteristics in the above fields. On the other hand, however, such a trend has recently grown strong enough for new use as an

element (a mechanical driving element), an actuator, to convert various kinds of energy into mechanical energy.

Its main application will be as a servo-displacement element for the hyperfine positioning of a precision machine tool and laser optical system; a pulse drive motor making up a printer head and an inchworm-type moving mechanism; and an ultrasonic motor suitable for driving a robot's hand and floppy disk (FD). Thus, it is now in the stage to be widely examined as an element to electrically control microdisplacement of the order of submicron.

Commercial Production in 2 Years

Toyo Soda and Assistant Professor Uchino have recently developed a completely new piezoelectric ceramic actuator element serving these purposes. They harbor great expectations that this will be the element that will solve once and for all the problems involved in the existing elements and be able to contribute to the development of microelectronics. Toyo Soda reportedly intends to start its commercial production in 2 years on the basis of this development. The difference between this new piezoelectric ceramic actuator element and the existing ones is as follows.

When applied electric pressure, the element which has recently been developed, generates a "bending phenomenon," it consists of only one sheet of unpolarized ceramics. A bendable, that is, flexible and deformable element has existed until now. It has been proved, however, that when applied electric pressure, the original piezoelectric ceramics, in case it is polarized, develops uniaxial expansion and contraction vertically or horizontally, but does not bend. Therefore, ceramics consisting of only one sheet can never develop a bending phenomenon logically. Until now, a bendable element has been produced by bonding a piezoelectric ceramic plate to a flexible shim (metal plate) and forcibly converting the deforming phenomenon into bending from expansion and contraction. So, "one sheet" represents the new feature of the piezoelectric actuator elements.

Toyo Soda calls this new product a monomorphic type against the unimorphic type, an existing piezoelectric ceramic plate lined with a flexible shim, and the bimorphic type, two sheets of piezoelectric ceramics sandwiching a shim in between.

What was the key point in the development of this monomorphic type? "In case a ceramic plate is provided with piezoelectricity, if the uneven distribution of an electric field is made to develop inside, it is expected to bend and deform," said Assistant Professor Uchino. This concept was faithfully put into practice during the development.

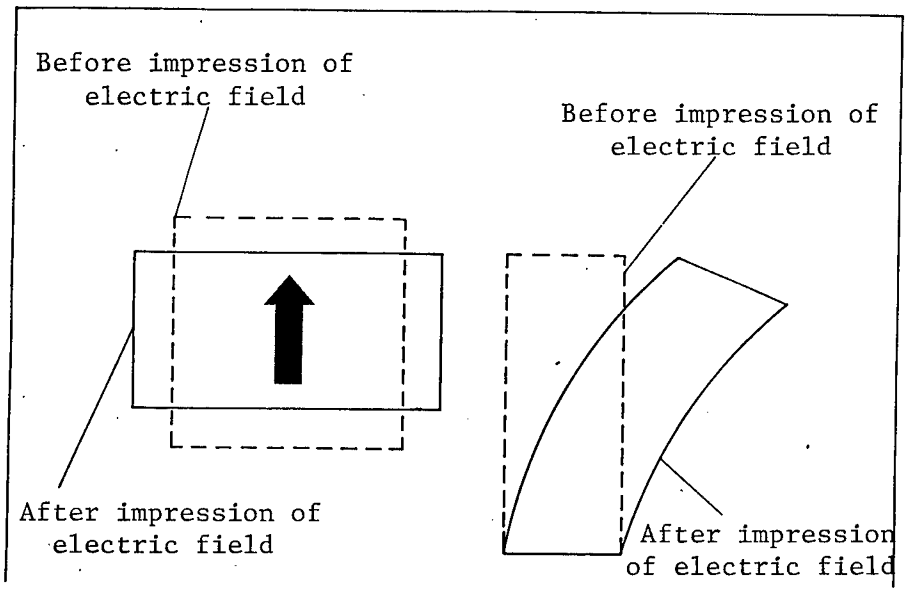
To begin with, there are two methods in developing an uneven electric field in ceramics.

One method is to generate an electric field by attaching an electrode to ceramics and developing contact resistance between them to generate potential. Another method is to make relatively semiconductive ceramics first by baking

ceramics and subsequently cooling it rapidly, and then oxidize its surface by heating gradually. By this process a semiconductor and an electrode are produced on the surface of and inside ceramics respectively.

Piezoelectric Ceramics Having Uneven Distribution of Electric Field

The piezoelectric ceramics having the uneven distribution of an electric field has been developed by all these methods. It was finished by adding impurities such as silica and alumina to control the conductivity at a high level. When the ceramic plate manufactured this way was sandwiched in between metallic electrodes, such as a silver electrode and applied electric pressure, the uneven distribution of an electric field developed inside, and as a result, it showed a "bending phenomenon" as Assistant Professor Uchino predicted, even though it was one ceramic plate.



(a) Ordinary piezoelectric material
Polarized piezoelectric material shows even expansion and contraction in vertical and horizontal directions

(b) New flection and deformation
Flection is available without polarization

Figure 1. (a) and (b)

Toyo Soda manufactured for tests an element 45 mm long, 0.5 mm thick and 15 mm wide through the above-mentioned processes from ceramics of the barium titanate and lead zirco-titanate systems, original raw materials, which have a great piezoelectric constant and are easy to develop semiconductivity. When a voltage of 6 kV/cm was applied to one end of the ceramic plate held, as large a flection of 100-500 μm as can be seen by the naked eye was developed at the other end. This flection is nearly

proportional to voltage and favorable test results have reportedly been obtained in regard to the frequency dependence that offers an index at the time of high-speed drive.

Costs One-Third

Next, explanation will be made about the difference between the monomorphic type piezoelectric ceramics and the bimorphic and unimorphic types, and the merits of each.

First, with respect to the existing types, it was necessary to give it polarization treatment under a high temperature (about 100°C) and high voltage (about 10 kV) in the process of manufacturing piezoelectric ceramics, a basic material, and additionally, it was unavoidable to bond it to a flexible shim. On the other hand, the monomorphic type does not require such processes at all, making it possible to simplify the production process and consequently have the price advantage to keep its cost to one-half to one-third. In addition, it has effects in terms of technology and quality. In particular, the bimorphic type, an existing type, is being widely used because it shows great flection easily, though it is not high in developmental power and response speed. Some experts, however, have pointed out its defects: 1) Low durability against repeated use (10^8 cycles). 2) Changes in flexibility (a creeping phenomenon). Both defects are problems attributable to its bonding to the shim plate; when used for a long period, the piezoelectric ceramics and the flexible shim creep gradually, resulting in such defects. However, the existing types which were considered unable to obtain flection without bonding to metal, could not avoid such defects. The monomorphic type is different in this respect. Since this type finds no need of bonding, there is no cause for it to deteriorate its function due to long use, so that the durability of the element and the stability of its flection could be easily improved.

The monomorphic type has such characteristics that in the volume of displacement it equals the bimorphic type, which is widely used for its flection as large as 100 μm, and it is easy to make any desired form.

Use for Piezoelectric Fans, etc.

Among the forms of application as an actuator, the following use is being considered by Toyo Soda to take advantage of the above-mentioned merits.

The use that comes first is as an actuator making use of the great flection as particularly shown in piezoelectric fans and pumps. The company intends to extend its application in this field in the initial stage, by making use of the merit of noiselessness the existing magnetic materials (the electrode system) lack and the great flection of the level equal to the bimorphic type. In the next stage, the company plans to use the monomorphic ceramics as acoustic elements for piezoelectric buzzers and speakers by making use of flection-vibration in audio-frequency, and further as microdisplacement elements for precise positioning in the fields of optics and precision machinery. The company intends further to replace the existing types in

other broad fields than the above. The monomorphic type consisting exactly of one sheet of ceramics has various merits other than those mentioned above such as being thin and light. It seems natural that a new application making the most of these merits will be developed to meet the industry's trend in seeking products that are light, thin, short and small.

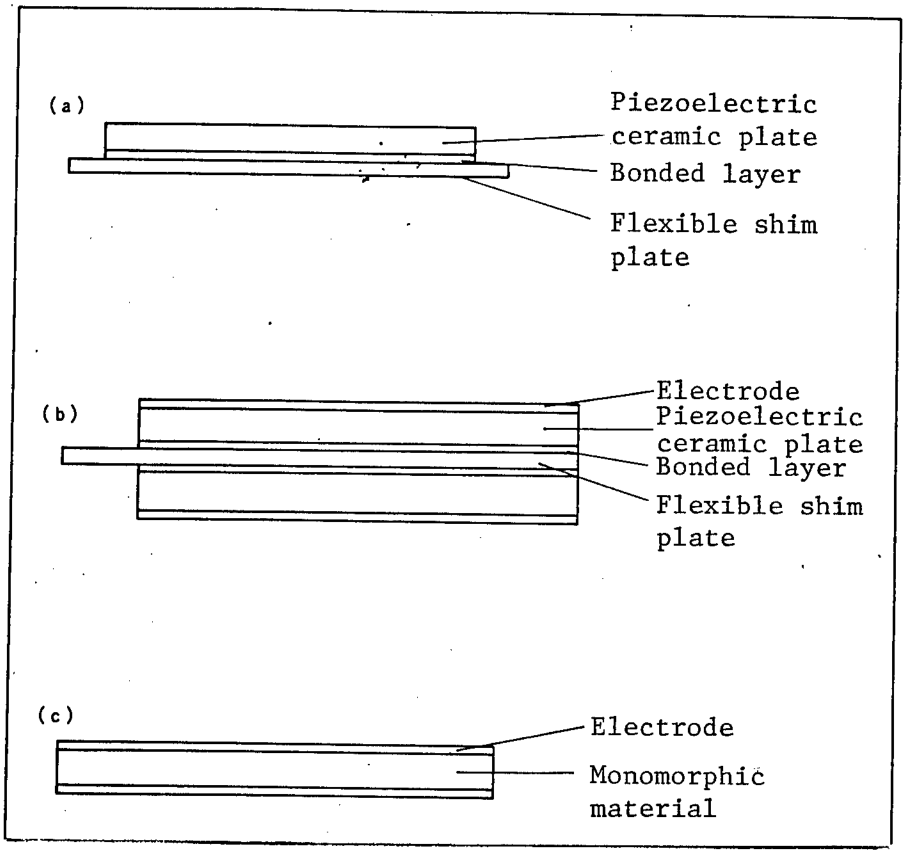


Figure 2. Comparison of Structure of (a) Unimorph, (b) Bimorph and (c) Monomorph

So far, description has been made of the merits alone of the monomorphic type; its demerits will now also be introduced.

To begin with, let us go back to the starting point of the monomorphic type ceramics. It consists of one ceramic plate. Therefore, it can be stable functionally and reduce the cost considerably as has been reiterated already. These merits, however, produced one demerit; this is in regard to intensity. When moving something by means of its great flection, the actuator naturally has to bear a great load. Since the bimorphic and unimorphic types are bonded to metal, they are relatively strong enough to bear the load. The monomorphic type, having no metallic support, is weak for the load compared with the existing types. This is a matter of antinomy and there is no sign of a successful solution to this problem at present. Although Toyo Soda is making studies of this drawback, there is, on the other hand, an opinion

that in the case of a heavy load the existing types should be used instead. At any rate, it is believed this problem will be solved in the course of practicalization.

Next, description will be made of the laminar type piezoelectric ceramic actuator, which has recently become as central a topic of conversation as the monomorphic type.

Great Developmental Power and Quick Response

The laminar type is basically an actuator laminated with plate-shaped elements and only expands and contracts. It does not bend or deform like the bimorphic, unimorphic and monomorphic types, of which mention has already been made. This laminar type, however, can obtain comparatively large displacement at low voltage by piling many layers, each having thickness as thin as possible, and has the following characteristics: 1) The developmental power is large. 2) It can stand a heavy load. 3) The response is quick. Since new systems such as the internal electrode system and ceramic electrode system, both are the improvements of the existing systems, have been announced in addition to the bond-type system which had so far been the trend, the concern about the actuators having such structure has grown greater.

At present, the application of the laminar type piezoelectric ceramic actuator to a microdisplacement element, high-speed displacement element and pressure generation element is being actively stepped up.

The bond-type is made by sticking together with an adhesive a number of piezoelectric disks (each 0.2-1 mm thick) coated with electrode. If finished properly, a bond-type actuator having considerably high reliability can be produced, but it has demerits. Productivity is low due to the excessive number of production processes and the driving pressure cannot be reduced because of the inability to make each disk thinner beyond a certain extent due to restrictions on processing.

A system capable of improving these demerits by raising mass-productivity and reliability, and reducing driving pressure is the internal electrode system. In order to produce this system a number of green sheets of ceramics are printed, thermocompression-bonded, and then sintered together with ceramics as it is containing the electrode inside. This is the system that provided the laminar type piezoelectric ceramic actuator an opportunity to attract public attention. Because the electrode is sintered together with ceramics, however, expensive platinum and silver have to be used as a metallic electrode so that the cost of the element becomes high. Additionally, its mechanical brittleness has been questioned by some experts. Then, came the ceramic electrode system as an improvement of this system. This new system is represented by the barium titanate actuator, which uses barium titanate ceramics for its electrode layers and combines it with insulating BT ceramics. This actuator is superior in the strength of bonding an electrostrictive strain driving layers to electrode layers, and generally believed to be fit for use in a place subject to large mechanical stress such as the positioning

of a machine tool which requires no high-speed alternate drive for hours causing heat generation. The studies on compound electrode materials having high specific conductance seem to remain a future task.

Excellent "new faces" have been developed among piezoelectric ceramic actuators such as the above-mentioned monomorphic type and this laminated type of the ceramic electrode system to meet the severe demands of the electronics industry for improved quality and functions.

If piezoelectric ceramic actuators are regarded as a device, they should rather be called a mechatronic device. Not only in this field, but also in the different field of ceramic devices, active developmental efforts are being exerted. In the field of ceramic devices other than mechatronic devices, active developmental activities are being carried out.

Great Expectations of Microelectronic Field

In the field of microelectronic devices, for example, development of parts for packages, chips and microwaves is being carried out urgently as lightness, thinness, shortness and compactness are called for in this field. In the area of ceramic substrates used in package parts, ceramics of the alumina-glass system, BaSn $(BO_3)_2$ system, SiC-BeO system and AlN system are attracting public attention as a low-temperature sintered substrate and high conduction substrate in place of the existing alumina substrates. In the area of SAW filters, representative chip parts, new crystals such as lithium of boric acid, etc. have come to be examined for the purpose of improving their functions. Accompanying the launching of car telephones and satellite broadcasting, a variety of dielectric materials have come to be used for microwave parts and some examples of their practical use are already available.

In the area of optoelectronic devices, glass for optical fibers comes first. Although quartz and multicomponent glass are presently used, the practicalization of fluoric glass is being actively carried out at present, because it is considered superior in terms of marginal transmission loss. Besides, there are some other movements such as the development of translucent ceramics as PLZT and zirconia.

As a display device there is an electrochromic display (ECD) and electroluminescence (EL). Since Bell Laboratories of the United States has announced a thin film type element called "Lumosen," which has the potential to provide high luminance and pleochroism, and another thin film type element having a double insulating layer has achieved higher luminance and longer useful life, electroluminescence has recently come under the spotlight.

Thus, active movements toward the 21st century have been seen across the board in the field of devices using ceramics, that is, electronic ceramics. The demands of the electronics industry are never-ending, however. A cry for the further appearance of new electronic ceramics will become louder in the future. The ceramic industry will have to expedite further the development of new products accordingly.

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CSO: 4306/7548

RECORDING MATERIALS FOR OPTICAL DISK MEMORY DISCUSSED

Tokyo CERAMICS JAPAN in Japanese Dec 86 pp 1,077-1,083

[Article by Tsutomu Ueno, Research Center, Daicel Chemical Ind., Ltd.]

[Text] 1. Introduction

With the compilation of various technologies such as the semiconductor laser technology, processing technology on hyperfine structures, and signal processing technology, video disk devices, and compact disk devices using the optical disc exclusively for regeneration are rapidly becoming popular. An impetus has been provided by this success on the development of optical disc devices such as the postscript type device with a higher level which allows the user to write and make additional recording each time information is generated and the rewrite type optical disk device which allows the user to write, erase, and rewrite. It is said that the practical use on the postscript type device has progressed in document filing, etc., and that the rewrite type device is in a state just prior to practical use.[1)]

Since the functions of postscript and rewrite are revealed by the recording materials used for the optical disk, the recording materials have come to occupy an extremely important part in the optical memory. Therefore, this development has also been promoted from various fields. Other types of recording materials have already been introduced in this journal.[1)-3)]

In this text, we will avoid duplicating those that have been already introduced and discuss characteristics of recent representative optical recording materials and those that hold promise for the future.

2. Recording by Hole Formation

A film of a material with a low melting point, low heat conductivity and high light absorption is formed on a substrate and laser beam is irradiated. This is the method which forms a hole with a diameter of about 1 μm in this part by heating in several tens to several hundreds of nanoseconds. This method is considered advantageous in cost and longevity.

2.1 Te system

This film material had been initially studied by using Pb, Ti, and Bi. However, since Te has a lower heat conductivity in comparison with other films having the same degree of laser beam absorptivity as shown in Table 1, it was regarded as having a high recording sensitivity and it came to be widely used.

The formation of the hole is due to the melting and vaporization of the film and the lowering of the surface tension caused by the temperature rise of the irradiation part. When a hole reaching down to the substrate is formed in the central part of irradiation (highest temperature), the melted part is protuberant in the periphery due to surface tension and the hole becomes completed. There is also the conception that the volume of this protuberated part is 60 to 70 percent of the film volume that existed in the interior prior to the hole opening and the balance of 40 to 30 percent has evaporated.[4] According to recent consensus, however, the experimentally obtained energy threshold value required for the hole formation far exceeds the energy required for melting the part. It has been said that the portion moving to the protuberated part is within the experimental error and the idea that vaporization has occurred is not supported.[5]

Since the shape of the hole affects the contrast and C/N of signal read, a round shape that is not disordered is preferred. The thing that controls this shape is the viscosity coefficient of the film and when this coefficient of viscosity is high, disorder on the contour part is small in hole formation even when there is a slight unevenness on the substrate surface. Since Te and Se have an atomic array that continues in a chain-like shape, the coefficient of viscosity is higher than usual metals. When Pb, Ge, etc., are added to this, it is considered that a crosslinking will generate in the chain-shaped array, the coefficient of viscosity will become higher and a good effect will be produced for the hole shape.[4]

However, the Te film is susceptible to oxidation. It is covered with an oxidized film when left for 10 days in room temperature and the reflectivity declines. The declining of reflectivity becomes further remarkable when the temperature is high.

Se is not susceptible to oxidation as Te is. When Te is oxidized near the surface in a Te-Se system film, it is considered that a high concentration part of Se not susceptible to oxidation is formed towards the internal side of the oxide layer. The progress of oxidation is prevented by mutual cooperation between the Te oxide layer and Se layer.[4]

From such a development, it was found that the sputter films of the Pb-Te-Se system,[4] Te-Se-Ti-Ag system,[6] and other systems using Te had a high sensitivity and durability. They had come to be mass-produced for document filing, etc.

2.2 Te-C system[9]

When sputtering of Te is made in CH_4 gas, a film of Te:C:H = 60:20:20 atomic percent is available. It becomes a condition where the Te particle group of

about 30 Å is surrounded by the alkyl molecular group in which groups such as $-CH^3$, $-CH^2$, and -CH are linked in a straight chain shape. The alkyl molecular group evaporates by laser irradiation. The Te fine grain groups loosely bond and become a microcrystal film, melts at the melting point of Te and becomes a hole. It becomes as shown in Figure 1 typically when indicating this progress.

In addition to this film having a high oxidation resistance and dampproofness from its structure, its sensitivity is higher then that of the Te film. The reason for this is that it becomes more than 140 degrees C in about 10 ns after the laser irradiation, the Te microcrystal group only is left behind and the structure of this Te microcrystal group is one in which the heat generated does not readily escape and is used effectively. Moreover, the heat conductivity of the Te-C film is lower than that of the Te film. Optical disks using this film have been put to practical use in document filing, etc.

2.3. Organic system

The organic coloring material system is also being studied for the hole formation recording film. At the beginning, research was done on the two layer construction which combined the organic film and metal reflection film and the three layer construction which inserted a dielectric layer between the films of the two layer construction. In the recent years, however, one with a single layer construction using an organic coloring material which has a reflectivity close to that of metals is gaining attention. The film of the phthalocyanine coloring material[10)] is formed by vacuum vapor deposition, the methine system coloring material,[11)] and naphtoquinone dye[12)] are formed by vacuum vapor deposition and solvent coating, respectively; studies are made on them as single layer materials capable of recording with the semiconductor laser. High productivity and cost reduction by means of the application method are also expected.

3. Recording by Phase Change

The microheated part by the laser beam can be used for recording and regeneration in place of hole formation when, for example, it rapidly changes from an amorphous substance to a crystal and there is no great difference in reflectivity.

3.1. Postscript type

For example, the thin films of Sb_2Se_3 and Sb_2Te_3 are subjected to crystallization and blackening by heating at about the temperature of 160 degrees C and 70 degrees C, respectively. Since Sb_2Se_3 does not practically absorb light, the thin film of Bi_2Te_3 is placed on top and used, the light is absorbed by this layer and the generated heat is transferred to Sb_2Se_3 for blackening. This change is rapid and recording of the diameter of about 1 μm is possible in about 100 ns after the irradiation of the 4 mW semiconductor laser. Furthermore, it maintains a stability to the extent that there are no changes even when testing for about 1 year under the environment of 45 degrees C and 95 percent RH.[13)]

Table 1. Comparison on Thermal Properties of Te and Other Metals

	Te	Bi	Ti	Pb
Heat conductivity (cal/cm·s·°C)	0.004	0.020	0.052	0.084
Specific heat (cal/g·°C)	0.048	0.029	0.125	0.030
Density (g/cm^3)	6.24	9.75	4.5	11.34
Melting point (°C)	449.8	271.4	1,668	372.5
Boiling point (°C)	989.8	1,560	3,289	1,753
Heat of fusion (cal/g)	32.8	12.9	77.2	5.54
Heat of vaporization (cal/g)	93	156	2,100	205.1

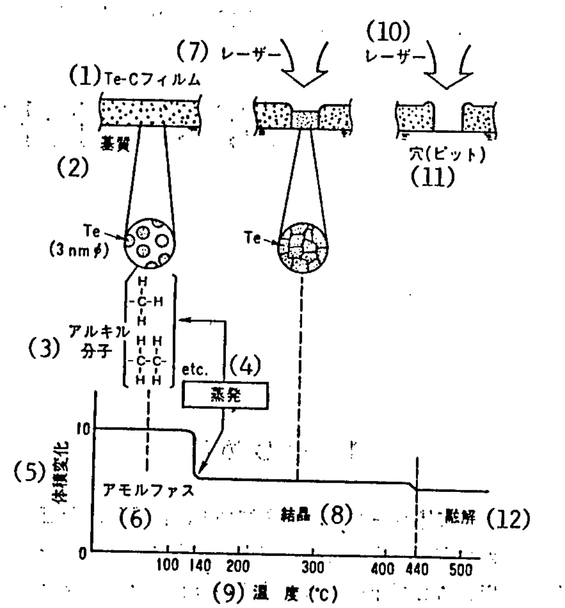


Figure 1. Structural Change of Te-C Film by Laser Heating[9)]

Key:
1. Te-C film
2. Substrate
3. Alkyl molecule
4. Vaporization
5. Volume change
6. Amorphous
7. Laser
8. Crystal
9. Temperature (°C)
10. Laser
11. Hole (pit)
12. Fusion

When the laser beam is irradiated on the TeO_x (0 x 2) film that has been subjected to a binary vacuum vapor deposition of TeO_2 and Te, it changes from an amorphous substance to a crystal; as the reflectivity is changed, recording and regeneration become possible. Disks using the thin film of TeO_2/Te = 1.22 have an excellent sensitivity and stability, and details on these disks have already been explained in this journal.[3]

3.2. Rewrite type

By changing the irradiation condition of the laser beam, the film adding a small quantity of Ge and Sn to the Te oxide reversibly changes the amorphous phase (recording condition) available by heating and quenching and the crystal phase (erase condition) available by slow cooling and becomes applicable for the rewrite type disks. Details on this have also been introduced in this journal.[2]

Moreover, it has been discovered that those of the Sn-Te-Se system films with a high content of Se have a high stability in the amorphous (recording) condition at standard temperature and that they are subjected to a high-speed crystallization (erase) by laser beam irradiation. Thus, they become the candidate for the rewrite type recording material and as shown in Figure 2; details including their behaviors against laser power have been introduced in this journal.[3]

Similarly, the reversible recording characteristics have also been recognized in the Ga-Te-Se system,[14] and as shown in Figure 3 under the composition of parylene/$Te_{0.7}$ $(Ga_{0.1}Se_{0.9})_{0.3}$/parylene/glass, the recording and erase areas can be classified similarly as in Figure 2 by the pulse width and power of the laser. According to the content of Ga, those without any change in characteristics were discovered even after leaving for 380 hours in the conditions of 50 degrees C and 70 percent RH, and studies aiming at improvements on the erasing speed and reliability are also promoted.[14]

Materials capable of applying the phase change between crystals have also been discovered. The Ag-Zn system alloy film made by the sputtering method has a crystal size of about 0.1 μm, changes to a pink color when water cooled from the temperature of more than 290 degrees C, changes to a silvery white color when cooled after heating up from 140 degrees to 285 degrees C. These changes are used to cope with the recording and erase conditions.[15] Similar experiments are also made in the Cu-Al-Ni system, etc.[15]

Moreover, in the In-Sb system and In-Sb-Se system alloys, there are also those that have been proposed as undergoing a change in reflectivity by the unevenness generated by the crystal phase difference due to quenching and slow cooling after heating for changing the deformation rate of the film.[16]

4. Recording by Inversion of Magnetization

4.1. Photomagnetic recording

When a laser beam is applied to a magnetic field that has been magnetized in the same direction, the temperature rises locally, the coercive force (H_c) of

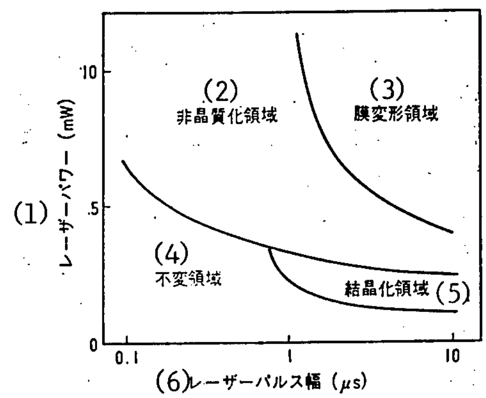


Figure 2. Relations Among the Laser Power, Laser Pulse Width, and the Condition After the Sn-Te-Se Film Irradiation[3)]

Key:

1. Laser power (mV)
2. Amorphous domain
3. Film deformation domain
4. Nonvariant domain
5. Crystallization domain
6. Laser pulse width (μs)

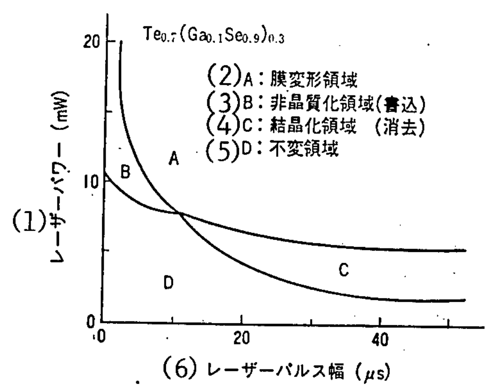


Figure 3. Relations Among the Laser Power, Laser Pulse Width, and the Condition After the Irradiation of the Parylene/Te-Ga-Se System/Parylene Film

Key:

1. Laser power (mV)
2. A: Film deformation domain
3. B: Amorphous domain (Write)
4. C: Crystallization domain (Erase)
5. D: Nonvariant domain
6. Laser pulse width (μs)

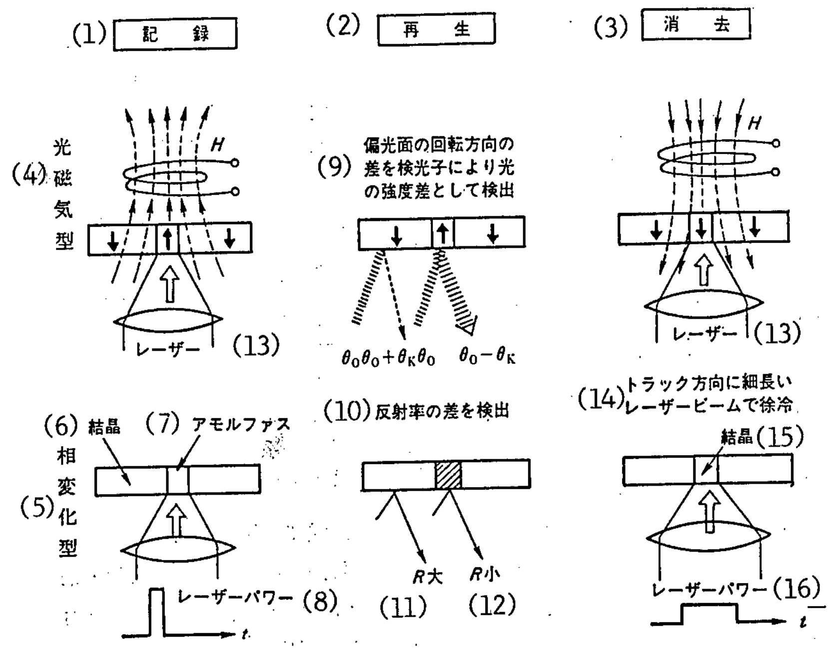


Figure 4. Comparison of Recording, Regeneration, and Erase Methods of the Photomagnetic Type and Phase Change Type[17]

Key:
1. Recording
2. Regeneration
3. Erase
4. Photomagnetic type
5. Phase change type
6. Crystal
7. Amorphous
8. Laser power
9. The difference in the rotation direction of the plane of polarization is detected as the light intensity difference by the analyzer.
10. Detects the reflectivity difference
11. Large R
12. Small R
13. Laser
14. Slowly cools with a narrow laser beam in the track direction
15. Crystal
16. Laser power

the film gradually declines and it becomes extinct at the Curie point. When a reversed direction external magnetic field is applied during cooling, the magnetization of the heating part can be reversed with that of other parts and recording becomes possible.

The linearly polarized light is usually applied to the magnetized film and the Kerr effect in which the plane of polarization of the reflected light rotates to the left and right according to the direction of magnetization is utilized for regeneration. When the difference on the plane of polarization is converted to the difference on quantity of light, the signal can be regenerated by this change. Moreover, when it is heated by the laser beam under an external magnetic field in the reversed direction to that when recording, the magnetization becomes reversed again and the recording is erasable. Since it is capable of recording and erasing by the direction of magnetization only and without accompanying mass transfer as done in the hole formation and phase change, it has the merit of withstanding numerous repetitions. In comparing the system of recording, regeneration, and erase with the system of the aforementioned phase change type, it becomes as shown in Figure 4.[17)]

The characteristics desired in this recording film are as follows:

1--High recording density: It is necessary to have an axis easy for magnetization in a direction perpendicular to the film surface; the lower the saturation magnetization (M_s) of the film, the better. Moreover, the minimum diameter in which an inversely magnetized magnetic domain of a cylindrical shape can stably exist in this film becomes smaller as the value of H_c increases.

2--High sensitivity: The laser power required for signal recording becomes low in proportion to the recording temperature and consequently the Curie point (T_c). However, when considering the balance with the thermal stability of recording in use, the temperature between 100 degrees to 250 degrees C is considered suitable for the recording temperature.

3--High contrast: The parameters in proportion to the recording signal are the Kerr rotation angle (0_K) and reflectivity. It is better when these parameters are large; there is no boundary in the film to cause noise.

4--High durability: There should be no changes in the characteristics even when recording, regeneration, and erasing are repeated. It should be thermally, mechanically, and chemically stable; the prolonged preservation of recording should be guaranteed.

4.2. Rare-earth elements--Transition metal films

A wide variety of recording materials aiming at the practical use of photomagnetic recording have been studied. Up till now, however, those that have been named as promising candidates are the amorphous films that have combined the heavy rare earth elements such as Gd, Tb, and Dy and the transition metals (TM) such as Fe and Co.

The vertical magnetized film is easily available by means of vacuum vapor deposition and sputtering for the RE-TM system containing Tb and Dy. The film coercive force (H_C) is high and the control of the Curie point (T_C) is also possible in this system as the composition ratio can be continuously changed. Among these materials, the Tb-Fe system is a favorable material in the characteristics concerning recording. However, the Kerr rotation angle (θ_K) is slightly low and C/N when composing the disk is insufficient. Therefore, the merits of the recording characteristics for the Tb-Fe were left as they were and various studies for increasing the Kerr rotation angle (θ_K) were made.

As a result of these studies, it was found that it settled down to about 0.3 degrees when the practical T_C of the RE-TM system was made 150 degrees C; it settled down to 0.4 degrees when T_C was made 200 degrees C and a drastic change could not be desired.[18)] A two-layered structure[19)] separating the recording layer (Tb-Fe) and regeneration layer (Gd-Fe-Co), and a structure placing a dielectric layer and reflection layer in the front and back surfaces of the film and also applying the Faraday rotation angle (θ_F) by light transmission have also been studied.

RE-TM films are rapidly corroded in a high humidity atmosphere. The style of corrosion can be classified as follows.[21)]

1--Pitting corrosion that is accelerated in high humidity.

2--Change of Kerr rotation angle (θ_K) due to surface oxidation.

3--Change of film coercive force (H_C) due to selective oxidation of RE.

One of the measures for corrosion prevention is the method of adding the additive shown in Table 2 to the film.[21)] The optimum additive suiting the film component is selected.

Another measure for corrosion prevention is the method of providing an anticorrosive coating on the film and as for the oxide system coating, SiO[22)] and the mixed oxide system (Figure 5)[23)] are said to be effective. In the nonoxide system, a protective effect has been recognized in Si_3N_4, AIN,[24)] and SiC.

Materials that have been investigated for the photomagnetic disk are either said to be in the stage of barely satisfying the lowest demands on generation characteristics of informations or achieving the stage immediately before entering into practical use.

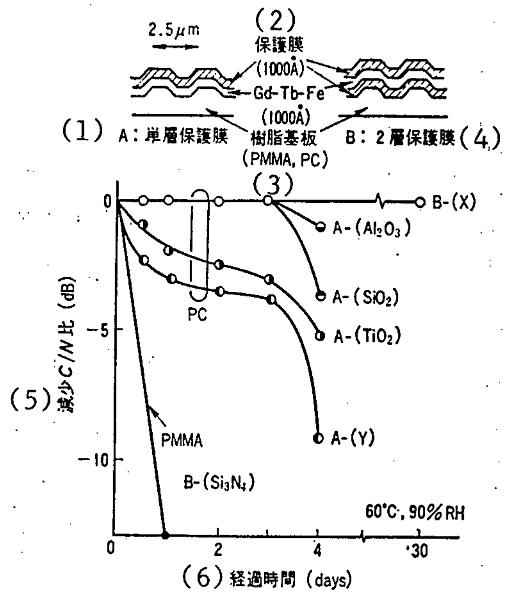
4.3. Magnetic oxide films

The Faraday rotation angle (θ_F) per unit length for films such as those of the YIG system and spinel system is not so large in comparison with metallic films. However, the absorption coefficient is small; according to the wavelengths shown in Figure 6, a thick film is usable as it nears transparency and resultingly, a large Faraday rotation angle (θ_F) can be used. Of course, there are no problems of oxidation and corrosion. In the recent years, the

Table 2. Effects to the Kerr Rotation Angle (θ_K), Oxidation Resistance and Corrosion Resistance by the Additive Content Added to the Tb-Fe and Tb-Co Systems

Additive Component	Tb-Fe System				Tb-Co System		
		Oxidation Resistance		Corrosion Resistance		Oxidation Resistance	
	Effect of θ_K	Surface Oxidation	Selective Oxidation	Pitting Corrosion	Effect to θ_K	Surface Oxidation	Selective Oxidation
Cr	↓	◎	◎	◎	↓	◎	◎
Al	=↑	○	○	◎	=↓	○	○
Ti	↑	◎	◎	◎	=	○	○
Ni	↓	△	▲	○	↓	▲	▲
Co	↑	△	▲	○	—	—	—
Pt	=↑	◎	△	—	—	—	—

◎ : Effect is conspicuous
○ : Effect exists
△ : Effect is small
▲ : No effect
↑ : Increases
↓ : Decreases



(7)PC：ポリカーボネート，PMMA：ポリメチルメタアクリレート．図中の（ ）内は保護膜の材質を示し，X：ガラス系，Y：酸化物系

Figure 5. Disk Structures A and B and Change of C/N With the Passage of Time[23)]

Key:

1. A: Single layer protective film
2. Protective film (1,000 Å)
3. Resin substrate (PMMA, PC)
4. B: Two layered protective film
5. Decreasing C/N ratio (dB)
6. Lapse of time (days)
7. PC: Polycarbonate; PMMA: Polymethylmetaacrylate, Chemical formula in parentheses in the diagram indicates the material quality of the protective film; X: Glass system; Y: Oxide system

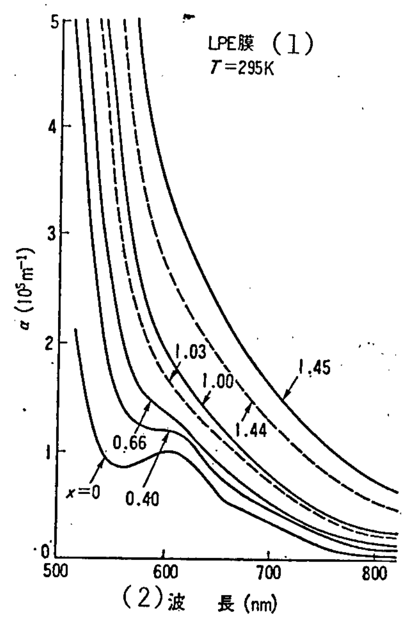


Figure 6. Wavelength and Absorption Coefficient of Y-Bi Iron Garnet Film ($Y_{3-x}Bi_xFe_5O_{12}$) (Dotted lines indicate the case when impurity Pb is low.)

Key:

1. LPE film
2. Wavelength (nm)

uniform film forming on the following films has become possible and they are attracting attention as the photomagnetic materials for the next generation.

1--Garnet ferrite: It is known that the magnetooptical effect of the magnetic garnet film is drastically increased by the substitution of Bi.[25] For example, there is the report that the film which has been subjected to sputtering on a high temperature glass by the $Bi_2YGaFe_4O_{12}$ target becomes a vertical magnetized film under the heat treatment of 600 degrees C. The Faraday rotation angle (θ_F) becomes 2.5 deg/μm (633 nm), the coercive force (H_C) of the film becomes 450 Oe, a Cr reflection film has been provided, write has been made with the 40 mW Ar laser and read has been made by 3 mW.[26]

There is also the method of blending the garnet component with nitrate, applying this blending dissolved in water on the substrate and allowing crystallization by heating.

2--Spinel ferrite: In case of $CoFe_2O_4$ which has accumulated a nitrate solution containing ion of the composition aimed at by atomizing on a high temperature substrate and crystalling it by heating, a large apparent Kerr rotation angle (θ_K) as shown in Figure 7 has been available with the 780 nm beam when it has been further enhanced with the SiO_2 film. Since this method requires the heat treatment of the film, it is difficult to directly cut a groove for control on the heat-resisting substrate. Therefore, a disk that has glued together a plate provided with a groove as shown in Figure 8 has been trial manufactured; it has been announced that write is possible at 15 mW by the 752 nm beam in 50 ns.[28]

3--Hexagonal magnet plumbite: The single crystal is already known as the photomagnetic material. Since the Curie point (T_C) of these materials is about 450 degrees C, their application as a recording material is difficult. Therefore, a portion of Fe has been replaced with another element, T_C has been lowered while maintaining the required coercive force (H_C), and recording and regeneration by means of the semiconductor laser have become possible.[30] For example, the film that has been subjected to sputtering on a high temperature GGG with $BaFe_{12-2x}Co_xTi_xO_{19}$ (x=0.75, 1.0) as the target indicated the lowering of T_C and the rise of the Faraday rotation angle (θ_F) together with the increase of x, and a magnetic domain with the diameter of about 1μm was made by the recording with the semiconductor laser.

Furthermore, it was considered that the multilayering of the recording film was possible when applying the wavelength characteristics of the oxide system film and basic research on realizing the two layer system is also underway.[32]

5. Conclusion

The outline on recording materials for optical disks of the postscript and rewrite types has been mentioned in the foregoing text. Considerable development is further necessary for these recording materials to satisfy all demands on optical disks including factors such as large capacity, possibility of high-speed access, long life and economy, and the possibility is also high that newer recording principles and materials will turn up in the future. Therefore, the forecast on what sort of recording material the optical memory

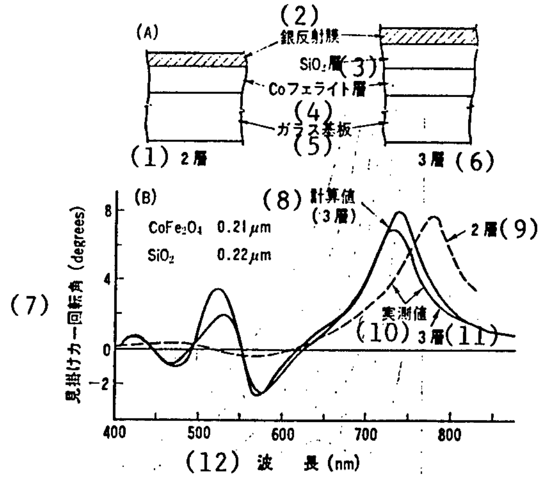


Figure 7. Disk Structure Using (A) Co Ferrite and the Calculation and Actual Measurement Values of the Apparent Kerr Rotation Angle by the (B) Wavelength

Key:

1. Two layers
2. Silver reflection film
3. SiO_2 layer
4. Co ferrite layer
5. Glass substrate
6. Three layers
7. Apparent Kerr rotation angle (degrees)
8. Calculation value (3 layers)
9. Two layers
10. Actual measurement value
11. Three layers
12. Wavelength (nm)

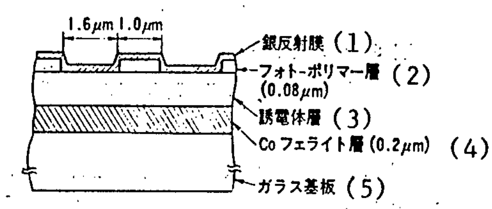


Figure 8. Composition of Photomagnetic Disk Using the $CoFe_2O_4$ Film

Key:

1. Silver reflection film
2. Photopolymer layer (0.08 μm)
3. Dielectric layer
4. Co ferrite layer (0.2 μm)
5. Glass substrate

technology will be integrated is difficult to predict at the present stage. It is considered that the putting of recording materials to practical use by matching with the applications that are making the best use of the respective characteristics will progress in the future.

FOOTNOTES

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STATUS, FUTURE OF DEFENSE ELECTRONICS INDUSTRY

Tokyo DENSHI in Japanese Aug 86 pp 38-45

[Article by Masatoshi Nakama, technical advisor of Japan Defense Technology Foundation]

[Excerpts] 1. Present Status and Future Defense Anticipation, Industrial Scale

In order to know the scale of the defense industry, it is better to refer to the tables and figures which show the actual results of weapons procured by the Defense Agency. Figure 1 shows the actual results of weapons centrally procured by the Defense Agency for 32 years, from 1954 to 1985. But these results do not include any repair parts for supply depots, etc. The total amount of weapons and equipment procured in FY 1985 was ¥1.1516 trillion. Growth of this money is at a stalemate, because there has been no gap between defense expenses and the limit of 1 percent of the GNP (gross national product) these past 3 years.

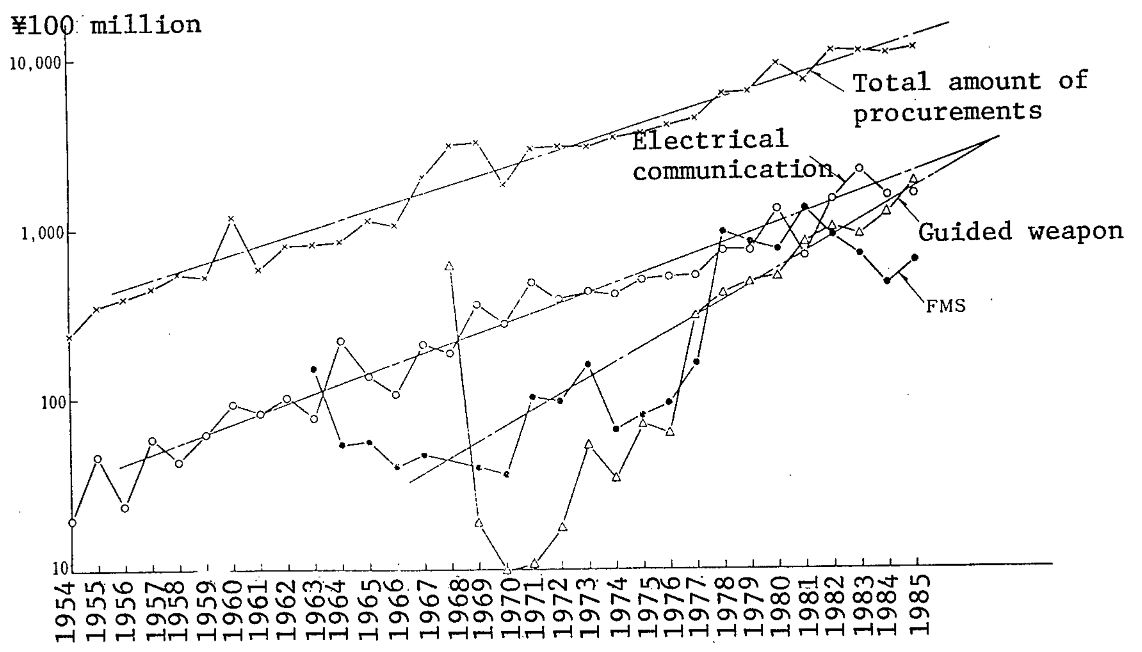


Figure 1. Defense Agency's Procurement Result Per Fiscal Year (Central Procurement Contract Base)

Presuming the growth tendency for the total period (see figure), the growth rate is "about 13 percent annually." The figure also shows electric communication, guided weapons, and FMS (foreign military sale) as electronic-related items out of the individually procured items. The FMS means the procurement between governments, i.e., Japan purchases weapons from the DOD (Department of Defense) of the United States. Recently, Japan has frequently purchased high-secrecy weapon systems which cannot be produced locally under license in Japan, such as missile systems for missile-loading ships, command and control systems, WES (weapon entry system), etc., because of the small number of weapons. The tables and figures show the growth rate of items related by electric communication is much higher than that of general items, being about 15 percent. The growth rate of items related to guided weapons fluctuated sharply in the past, but in the last 8 years, it is high, being about 23 percent.

I will now investigate the ratio accounted for by the electronic equipment in terms of all procured weapons. Assuming that about 80 percent of the guided weapons and FMSs are related to electronic equipment, the above ratio will be about 33 percent. Now, the numerator is regarded as a value to which percent related to electric communication is added, and the denominator is regarded as a value obtained by deducting an amount of money (¥30.6 billion) of procured trial-manufactured products from the total amount of money of all procured products. Recently, aircraft, ships, vehicles, etc., have been automated. Adding the percent of the gauge, microcomputer, sensor, etc., mounted on these aircraft, ships, vehicles, etc., to about 33 percent, the number will be further increased by several percent. According to the AEA (American Electronics Association), the ratio accounted for by the amount of money of electronic equipment in terms of the total amount of money of all procured weapons, has reached 39 percent. It seems that a value close to this figure will be obtained in Japan also. It can be estimated that the scale of the present defense electronic industry is about ¥380 billion with consideration given to the previously mentioned 33 percent.

It cannot be expected that this scale will increase in the future, unless the limit of 1 percent of the GNP is withdrawn. But, judging from the past tendency, it is anticipated that thedefense electronic industry will continuously increase from now on at an annual rate of 18-20 percent.

2. Relationship With Electronic Technology

When the Southwestern Rebellion broke out in Japan in 1877, electronic equipment was used as a weapon on a large scale for the first time. The electronic equipment was a wire telegraph. Before that time, electronic equipment had been used as a weapon on a small scale in Europe. According to a "Satsuma Rebellion Record" written by an Englishman, the Imperial Army had linked all distances between Kyoto and the Imperial Headquarters located in Taharazaka and between the Imperial Headquarters and respective brigade headquarters with wire telegraphic circuits, and the total length of all wire telegraph circuits including branch circuits had reached 33,000 miles.

Converting miles into kilometers, the above total length is about 50,000 km. This is equivalent to the distance around the globe one and one-fourth times.

Considering the technical and economic powers at that time, it can be considerably and highly evaluated. The communication leader was a captain, and the participation of many soldiers of the Engineering Bureau into actual communication work increased the fighting power. Communication circuits were used to supply provisions, ammunition, medical supplies, etc. as well as to report military situations and to take operational instructions. According to a book written by Genichiroh Fukuchi, the telegraphy was very powerful.

Subsequently, new equipment was developed to command and control the organizations. The new equipment was a wireless telegraph used in the Battle of the Japan Sea which broke out in 1905. The wireless communication transmitted from the Shinanomaru was famous, and supplied strategically important information to the allies. The wireless telegraph fully exercised its power not only in a strategic aspect but also in a tactical one. For example, it was easy for all ships to simultaneously make fleet manuevers, to take charge of firing at targets, to inform allies of firing data, to correct impact points, etc. The Togo Fleet made fleet maneuvers and immediately after it encountered the enemy, it started using a T-shaped strategy while conducting a cruising battle. This enhanced the strike probability of the allies' shells by concentrating all firepower on the enemy's important targets at the closest range, and completely annihilated them by beating out respective enemy ships. According to Russia's record, they could not effectively use wireless telegraphs, nor could they make satisfactory fleet manuevers nor fire trial guns. Respective ships of the Baltic Fleet started simultaneously firing guns on trial, many columns of water went up, they could not tell their own column of water from others, and they were in a state of disorder from the start of the battle. After one of the ships of the Japanese fleet trial fired and corrected the impact point, it informed other ships of firing data by wireless telegraph, and all ships fired guns in accordance with this data. Therefore, they could fire a volley at enemy ships with considerably high accuracy.

Subsequently, new equipment was developed to command and control the military, and was used in the air war of the Battle of Britain conducted for about 1 month's time from 15 August 1940. The new equipment was a VHF (very high frequency) radar developed in England. This air war was started as an operation whereby immediately after Hitler conquered France, he would completely destroy England with superior German air force units consisting of 3,000 aircraft by taking advantage of the situation. But the German Air force units retreated in miserable defeat. The RAF (Royal Air Force) had already finished the maintenance of VHF radar network at that time, so it divined an invading course of the German Air Force in advance, and had Spitfire fighter squadrons ambush the enemy on the invading course. The Spitfire fighter squadrons concentrated their firepower on the enemy in a formation by using diving and striking tactics. After these Spitfire fighter squadrons finished the attack, they rapidly separated from the fighting field, again soared high in the sky, and repeatedly delivered an attack against the German Air Force in accordance with the allies radar guidance. In addition, they avoided conducting conventional one-on-one dogfights as much as possible. As a result, the German Air Force lost a chance to counterattack, was damaged successively, and was defeated due to the loss of 1,733 aircraft during 1 month. In the end, it was impossible for the German Air Force to continue to fight.

The German Air Force's Messerschmitt and the RAF's Spitfire were fighters with almost the same performance, but the damage ratio of both air forces was 7:3, i.e., damage to the German Air Force was more than twice that of the RAF.

A naval battle similar to the above air fight was conducted as the Japan-U.S. final battle at sea off the Mariana Islands on 19 and 20 June 1944. There were 450 Japanese Zero fighters that took off from 9 aircraft carriers including the Taiho, the flagship under the command of Vice Admiral Ozawa, and fought with the U.S. task force consisting of 15 aircraft carriers under the command of Vice Admiral Mitcher. The U.S. Navy's Grumman F6F fighter was superior to the Japanese Navy's Zero fighter in quality and quantity. Formations consisting of such Grumman F6F fighters attacked Japanese offensive air units by using the same diving and striking tactics as the Japanese offensive air units. Their control came from high-performance microwave radar emitted from their mother aircraft carriers. Also, in the same way, they avoided conducting one-on-one dogfights, so Japanese Zero fighters were shot down in succession without any display of the Zero's advantages, and the Japanese Navy was struck a disastrous blow.

The air traffic center is called DC (direction center). The BADGE (base air defense ground environment) is produced locally under license, and has been established in Japan. It possesses almost the same performance as that of the SAGE (semiautomatic ground environment). Fighters cannot carry out any interception missions without this ground electronic support facility. For this reason, even if DCs or radar sites for ground fixing facilities are destroyed, the mobile radar equipment, communication vehicle, and trailer mounting type DC have been developed so that they can be used instead of the destroyed DCs or radar sites. Also, the flying radar site mounted with large radar equipment and computers and the AWACS (airbone warning and control system) have been developed. This AWACS possesses the same performance as that of a DC. At first, this kind of electronic equipment was called C^2 (command and control system).

This is because the C^2 function is broadly classified into command function and control function, but very large computers are not required to control the weapon, aircraft, etc. The command function has been updated annually, because of an increase in the level of weapons and tactics. Particularly, in order to make command decisions, it is necessary to simulate tactics, etc., and to tentatively carry out intercepting attrition rate calculations, etc. Therefore, the high-performance data base and computer have been required to instantly know the results obtained from the above simulation and calculation. The C^2 has been called, C^3I (command control communication and intelligence), because high-speed digital computer circuits have become conditions indispensable for system configuration so that even if a DC is destroyed, the digital base of an adjacent DC can be used. In addition, this is because the input intelligence which makes the data base more effective, has increased. Recently, the military term "Data Base" has been used without any change in the nonmilitary world.

The role of C^3Is used mainly in an air war has been mentioned up to now. Considering sonar instead of radar equipment and the homing torpedo instead of

missile in the antisubmarine operation, a C^3I which is the same as the above C^3I can be obtained. Also, considering the pulse Doppler radar equipment and infrared detector (thermal video unit) as sensors and the antitank missile as an attacking weapon in the ground antitank warfare, an effective C^3I system can be obtained day and night. But, space does not permit an explanation of this system.

The reliability of missiles has increased, and these missiles have been developed up to a point where it is expected for them to hit their targets; a missile mishit is an exception. This is because recently, the performance and reliability of semiconductor technologies have increased and the sensors for EHF (extreme high frequency), infrared rays, etc. have shown marked progress. For reference, these EHF, infrared rays, etc. are necessary for the terminal guidance system and the inertial guided system which affect the strike probability of missiles. Therefore, first discovery of enemy and first firing of missiles, first victory.

William Perry, ex-secretary of defense (R&D) of the United States said about the above, "The discovered will be destroyed." But, only when missiles are jammed and their seeker sensors are put out of commission, will they be unable to strike any target. For this reason, it has become extremely important to develop technologies for ECM (electronic countermeasures) and ECCM (electronic counter countermeasures). These are known generically as electronic warfare. The only winner in electronic warfare makes its missiles hit targets.

Electronic warfare has a long history and dates way back to the age of the Russo-Japanese War. On 14 April 1904, two Japanese heavy cruisers, "Kasuga" and "Nisshin" shelled the enemy fleet lying in Ryojun Harbor. At that time, Japanese destroyers informed the two cruisers of the results after observing impact points outside the harbor. Operators at the Russian radio station intercepted radio messages sent from the Japanese destroyers to the above two Japanese cruisers and continued to send telegraphs. For this reason, the Japanese wireless telegraphs were jammed, and Japan could not attain her initial goal. This was the first electronic warfare in the world, and adorns the first page of electronic warfare history.

The next occasion where electronic warfare was used was the Tokyo air raid. On 10 March 1945, large formations consisting of 330 B-29s, heavy bombers carried out an air raid on Tokyo. The B-29 used to invade the enemy air space at an altitude of about 30,000 feet until that day, when the B-29s invaded Tokyo at an altitude of 700 feet. These B-29s were to fall victim to Japanese antiaircraft artillery units, because the altitude was within the range of the Japanese antiaircraft guns. But suddenly, the Japanese antiaircraft guns were jammed by the B-29s. A Ta-Go 3 Type VHF Plotter was interlocked with these Japanese antiaircraft guns. The surface of the CRT (cathode ray tube) of the Ta-Go 3 Type VHF Plotter turned white, and was completely put out of commission. Japan had reflections whereby at first, they should have emitted decoy radio waves and subsequently changed them to true ones. But, it was too late. Japan suffered a bitter experience in which she saw the end of the Pacific War on 15 August 1945 without any measures against the jamming tactics. It seems that there are many elders who had been engaged as student

soldiers in producing radiowave weapons during the Pacific War. I was also one such student soldier.

Research on radar technology has been conducted since the end of the Pacific War. The problem is how to decrease the degree of jamming. Some effective methods have been devised, and the most effective method is to compressively integrate the radar pulse. This method means that when radar pulses are modulated at the transmission side, they will be modulated with a certain code key, and when they are received, they will be demodulated with the same code key. The method seems to be satisfactory at first sight, but the intensity of codes is insufficient, and when radiowaves are detected and analyzed with computers for many hours, the code keys will be decoded. Then the spread spectrum modulation system was established as a new method. The use of this new method will successively change complex codes enough to be impossible to decrypt and will increase safety. The spread spectrum conforms to the American calling style, but the new method was not invented in the United States, because we Japanese had independently conducted research on the same system (ECCM communication). The spread spectrum modulation system means that the high-frequency radar waves are phase modulated with coded high-speed random number columns, and are devised so that persons who do not know any code random number can neither receive nor integrate radar waves.

The sideband wave energy is diffused to 1,000 times that of usual radar waves, because radar waves are modulated at high speed. Therefore, it is almost impossible to decode radar pulses, because even if these radar pulses are received with a usual receiver, the receiver can only catch them as extremely fine noise radiowaves.

3. Present Technical Subjects

In order to realize such hardware, it is necessary to provide a VHSCI (very high-speed integrated circuit) which can modulate radar pulses at high speeds. For this reason, the DOD started developing the VHSIC in 1982 so that it would be completed in 1986. This plan does not cover any GaAs semiconductor employing the next generation's technology, but covers an Si semiconductor employing an 0.5 μm-wire width processing technology. However, the service environmental conditions of VHSICs used for military purposes are different from those of VHSICs used in civil requirements. Assuming that the temperature rise is 45°C, the junction temperature will reach 170°C, because the service upper temperature limit is 125°C. The IC (integrated circuit) electric performance is that the FTR (functional throughput rate) 1×10^{13} gate hertz at a clock time of 100 MHz. (Clock time: internal cycle time)

The clock time is the driving pulse period of computers. Generally speaking, the logical circuit of computers requires time which is 70-80 times that of the delay time necessary for signal pulses to pass through the IC's logical gate, as a driving pulse period. This is because in order to make large computers execute basic instructions, signal pulses must be passed through the 10-piled gate, and there are many cases in which basic instructions are executed with several microinstructions in microcomputers to simplify the hardware. The FTR sounds strange, and it is indicated that gate hertz obtained

by multiplying the number of logical gates incorporated in an IC chip by the number of signal pulses which can pass through each gate in a second. For example, replacing the number of gates by machinegun muzzles and the number of such signal pulses by the fire rate of bullets, respectively, the total firepower can be expressed with the product of the number of machinegun muzzles and the fire rate of bullets. IC chips can drive at 1×10^{13} gate hertz. When such IC chips are used in computers and these computers are used in C^3I systems mounted in usual aircraft and ships, the processing speed of the computers will be 1,000 MIPS (million instructions per second). Therefore, it is expected that the performance of computers will increase sharply. In addition, it will be possible to manufacture special IC chips for electronic warfare.

It is uncertain whether or not the Soviet Union is making efforts to fully apply the highest technology based on the above electronics to military matters; the United States is the only country in the Western world which is making efforts to do so. At present, all other countries in the Western world are far behind the United States in this technology. However, European electronic manufacturers which have lagged behind the United States in semiconductor technology, are making efforts to quickly catch up with these U.S. manufacturers by buying off U.S. semiconductor specialized manufacturers which are suffering from a depression. This is to reverse the above imbalance and has obtained results to some extent.

Although European countries are in the above situation, Japan has grown enough to almost equally compete with the United States in the only department of civil requirements. It is estimated that Japan has the potential capacity concerning military IC technology. Up to now, the United States has carried out the development of weapons in collaboration with only NATO (North Atlantic Treaty Organization) countries, but she eagerly wants to do it in collaboration with Japan as well as the NATO countries, because of the above reasons. The United States has advanced a proposal on Japan-U.S. joint development of some weapons including the military IC. For this reason, some U.S. persons in charge of joint weapons development have visited Japan. This proposal is based on the anticipation whereby the Japanese Defense Agency's R&D cost will be ¥500 billion, which is about 10 percent of the United States because the Japanese military cost is less than 10 percent of the United States. But, the United States has decided to shelve the proposal because it has been clarified that the actual Japanese Defense Agency's R&D cost is ¥63.5 billion, which is more than 10 percent of the expected value. Accordingly, the United States has paid attention to the department of civil requirements in which Japan is investing large R&D costs, and has studied whether or not there are general-purpose technologies which can be used in military matters.

As a result, the United States has cited several items as candidates for such general-purpose technologies. That is, these items are the EHF microwave semiconductor device, GaAs semiconductor, laser equipment, optical processing unit, infrared imaging unit, VLSI (very large-scale integrated circuit), CAD (computer aided design), robot producing technology, etc. If national technologies developed with government funds are granted to the United States, there will be no problem in the grant, but if civil technologies developed with private funds are granted, it is anticipated that various problems will arise in the grant.

Even if these civil technologies are granted to the country, in principle, this grant will probably conform to the commercial basis.

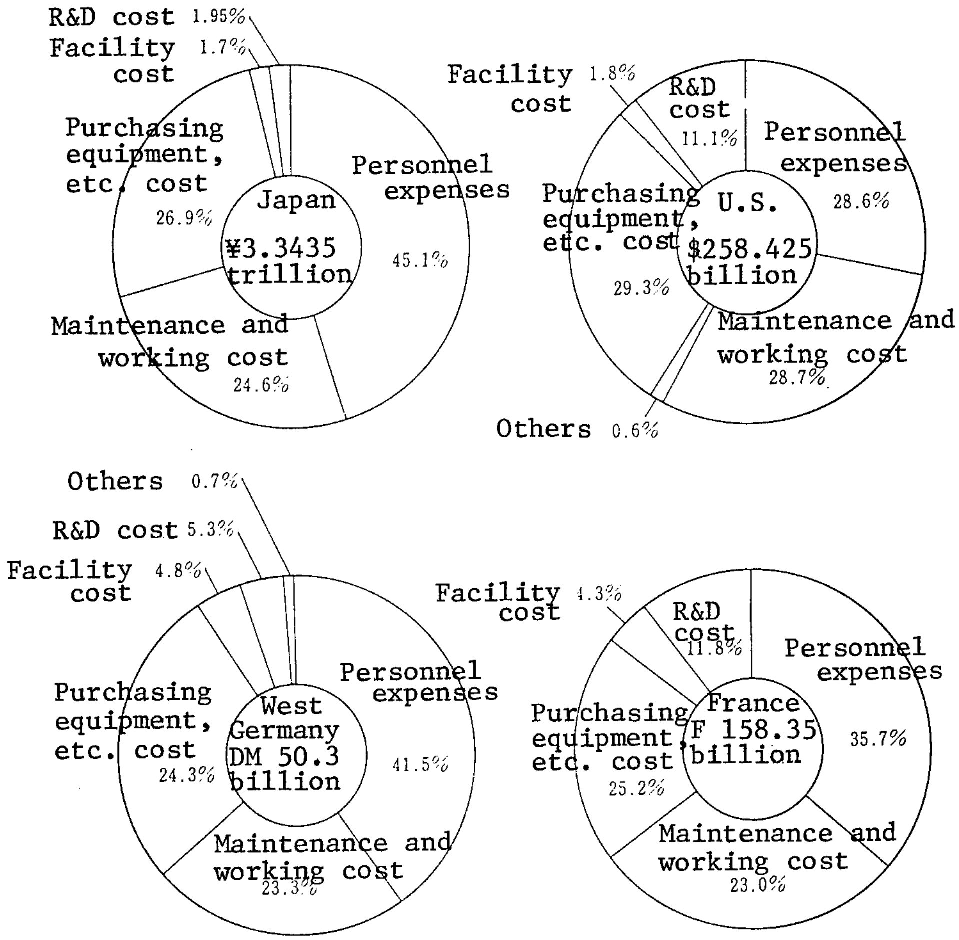
As previously mentioned, the present Defense Agency's R&D cost is very low, but the recent annual budget growth rate is high, being 20 percent. If this tendency continues for 10 years, it is expected that Japan will be able to soon shoulder a part of the international responsibility in the technical defense aspect as one of the Western-bloc countries. If she can do so, it seems that the joint development of the military IC related to an electronic field, etc. will create a sensation.

4. Cooperative System of International Technical Development

It is estimated that U.S. military costs and those of the Soviets are almost equal. But, it is also estimated that Soviet capital expenditures such as weapon purchasing costs, facility costs, R&D costs, etc. are extremely high and the total capital expenditures have reached 70 percent. This is because Soviet consumption expenditures such as personnel expenses, maintenance and working expenses, etc. accounted for in the defense cost are extremely low. The total capital expenditures of the Western-bloc countries are low. For example, those of the United States, France, West Germany, and Japan are 42.2, 41.3, 34.4, and 30.3, respectively. The rate of Japan's personnel expenses is the highest of other Western-bloc countries (Figure 2). Also, in the Western-bloc countries, the unit price of weapons is extremely high, because the personnel expenses of private companies are also high. Therefore, the number of weapons which can be purchased for the same amount of money is small. In addition, weapons manufactured in Western-bloc countries have become increasingly expensive, because these weapons are still multifunction and independently produced in small lots by respective countries. Because of the above reasons, the total number of weapons manufactured in the Western nations is much smaller than that of weapons manufactured in the Eastern countries.

England and West Germany have taken the lead in R&D of the ASRAAM (advanced short-range air-to-air missile), and the United States has followed. These two countries are competitively producing an ASRAAM on an experimental basis because they have disagreed with each other about the guidance control system. The United States has taken the lead in R&D of AMRAAM (advanced medium-range air-to-air missile), and England and West Germany have followed. Compared with the age in which respective countries independently developed similar missiles even if there were various problems, present day trends can be evaluated as a remarkably advanced age.

Figure 3 shows the ratio accounted for by the defense R&D cost in terms of the defense cost of major Western-bloc countries and the absolute amount of money. The ratio of the United States, France, and England was high, but England's has decreased since 1984 due to the influence of the Falklands war. The ratio of both Japan and West Germany is low. Particularly, that of Japan is extraordinarily low. In the case of West Germany, the allied powers have taken a line in which they have not permitted West Germany to conduct research on weapons or produce these weapons since the end of WWII because Germany



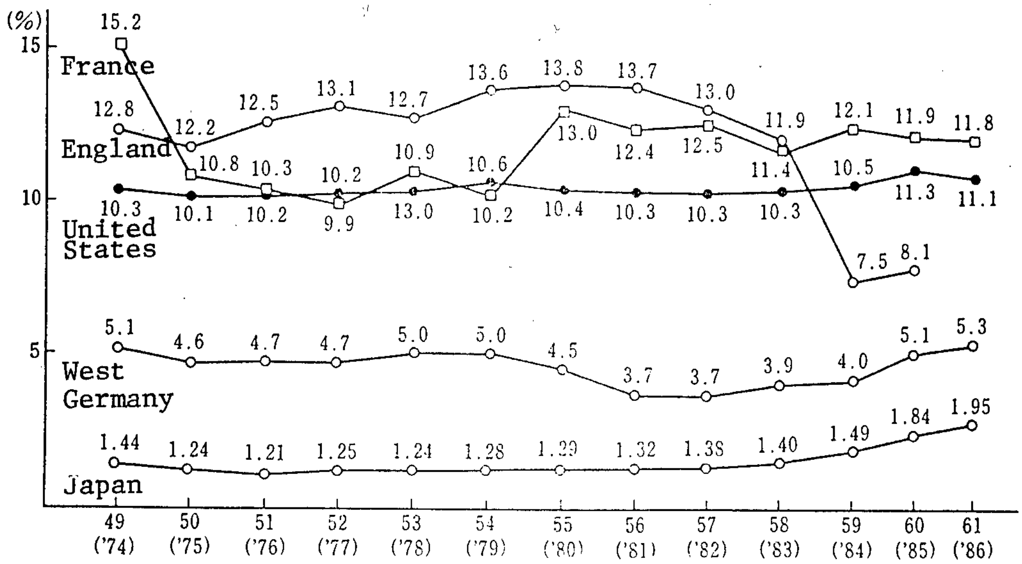
Note: It cannot be said that this classification is shown at the same level, because respective countries are different from each other in respect to accounting systems and military systems.

Extracted from data published by respective governments

Figure 2. Contents of National Defense Expenditures of Major Countries (FY 86)

invented too many revolutionary weapons during WWII. At present, this restriction is being removed from West Germany because it is unreasonable to impose such a condition on West Germany which is one of the major NATO countries. But the R&D cost is low because West Germany has been affected by the line up to now. Japan has not been affected by such a line.

Even if joint development or production of weapons is realized in the Western world, materials for electronic warfare would be exceptions. In the same way as cipher machines, these materials for electronic warfare are top-military secrets, and all processes from R&D to production, operation, and scrap of materials are tightly controlled. In many cases, these electronic materials



Extracted from Defense Yearbook published in 1986

Figure 3. Defense Research of Major Countries (Development cost)

Research Cost and National Defense Research Cost Borne by Governments of Major Countries

Division / Name of country (year)	Research cost (¥100 million)	Research cost borne by government (¥100 million)	National defense research cost (¥100 million)	Rate of costs borne by government (percent)	Rate accounted for by national defense research cost in terms of research cost borne by government (percent)
Japan (1981)	53,640	13,403	326	25.0	2.4
Japan (1982)	58,815	13,888	365	23.6	2.6
Japan (1983)	65,037	14,407	395	22.2	2.7
United States (1982)	200,070	92,299	45,917	46.1	49.7
United States (1983)	208,235	95,779	50,635	46.0	52.8
England (1981)	26,479	12,637	7,802	47.7	61.7
West Germany (1983)	43,515	18,399	1,682	42.3	9.1
France (1983)	26,432	15,273	5,648	57.8	36.9

Extracted from the 1985 White Paper on Science and Technology. It does not cover the rate accounted for by the national defense research cost in terms of research cost borne by the government.

are mounted as black boxes in various electronic weapons, but the life of the electronic materials is relatively short, because they will be replaced with new ones in accordance with R&D advances. Also, generally speaking, a random number of cipher generators cannot be used for a long time because they have periodicity. After they are used to some extent, it is necessary to replace them with new ones. Therefore, it is necessary not only to develop and produce such materials for electronic warfare, but also to uniformly control them for effective fighting through electronic warfare. At present, some electronic weapons are produced locally under license. Formerly, when these electronic weapons were in the latter period of licensure, the domestic production rate increased, but recently, this rate has not increased. This is because it is economical to import military ICs for electronic weapons from the United States.

As mentioned above, Japan's present defense electronic industry places reliance on only the import of materials, and promotes only assembly work of these materials. If this situation continues, the Japanese defense electronic technology will be ruined. It is all well and good for Japan to participate in research on SDI (Strategic Defense Initiative), but it is considered necessary for her to urgently establish a new defense electronic industry including problems of military ICs, particularly VHSIC. Of course, these problems must be solved. This establishment will quickly enhance Japanese security. In order to do so, she should inevitably give priority to the increase in defense R&D costs.

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DEVELOPMENTS IN DEEP-SEA EXPLORATION DISCUSSED

Kaiko Project

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 25-28

[Article by Kazuo Kobayashi, professor at Ocean Research Institute of Tokyo University]

[Text] 1. Kako Project To Investigate Trenches and Troughs

Kaiko Project is the popular name of the Franco-Japanese joint investigation of the Japan Trench conducted twice, once in FY 1984 and once in 1985. Kaiko is apparently the term "trench" written in the Roman alphabet, now becoming an international term; it is being widely used in theses, commentaries, and news in French and English.

The sea areas covered by this project this time are the Japan Trench, Nankai Trough, Suruga Trough, and Sagami Trough, the latter two connect the former two, and all of them represent entrances through which ocean plates sink diagonally under land. The Japan Trench was formed by the Pacific Ocean Plate and the rest by the eastern part of the Philippine Sea Plate when they slipped under the Japanese islands (Japan proper, Shikoku and Kyushu).

While the Pacific Ocean Plate is over 100 million years old, the eastern part of the Philippine Sea Plate is about 15 million years old, one digit younger. The reason Nankai Trough is shallower than the Japan Trench is this age gap. Although Nankai Trough is not called a trench, because Japan follows the old definition of the International Hydrographic Secretariat that requires the topography of the seabed to have a part deeper than 6,000 m to be called a trench, its formation factor is basically the same as that of a trench like the Japan Trench.

These subsiding regions make twins of a great fluctuating seabed belt together with the ocean central ridge area where an oceanplate rises and expands. If a central ridge can be compared to the boarding place for a descending escalator, the trench or trough represents the landing place. Any of them develops a number of cracks at the seabed and creates a group of steep cliffs in the seabed topography.

The survey of the pivot of the ocean central ridge in the Atlantic Ocean was carried out in 1973 and 1974 under the Famous Project, a Franco-American joint

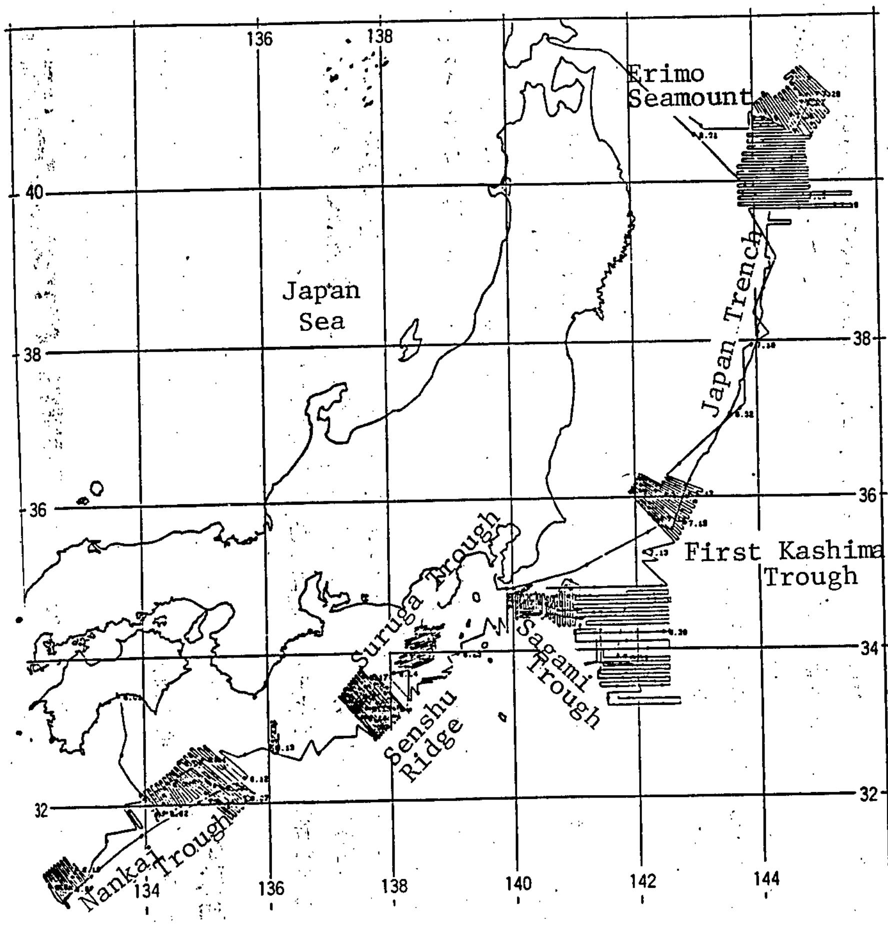

Figure 1. Sea Areas Surveyed Under the Kaiko Project (Submarine investigations were conducted at sea areas chosen from these areas 2 years ago.)

project, which literally became famous. The United States and France later discovered in succession the emission of thermal water, hydrothermal deposits, and a colony of bathybic organisms around the deposits in 1979 in the East Pacific Ocean Rise at latitude 21°N. By the way, the spot of thermal water emission was discovered in the Atlantic Ocean in 1985 around (Kein) rupture zone at latitude 24°N by the monitoring TV camera mounted on the drill pipe of (Joydes) Resolution, a new bathy-dredger and the heavy metal deposit was sampled then.

"The next target after the ridge is the trench" became a sort of slogan among seabed researchers in the world and trenches in the world came to be noticed. France sounded out Japan right after the completion of the Famous Project on a plan to survey Japan Trench by using its own submarine survey vessel. Although Japan had a stock of survey data about the Japan Trench collected by universities, the Hydrographic Department, the Geological Survey of Japan, etc. it was one step behind in the technical capability to perform precise surveys by use of new methods including a submarine survey vessel. Since the French team included (Rupicion,) one of the founders of plate tectonics, and

(Oboin), the most prominent figure in the geological world, the joint research was expected to benefit Japanese research beyond a technical aspect.

Based on this recognition, representatives of both countries worked out a concrete program between 1980 and 1982 through thorough discussions covering scientific, technical, and financial aspects of the project. During this period academic contacts and human relations were established between these two parties through the exchange of several researchers, apart from meetings of other representatives.

It was keenly felt that it is quite necessary to have such a preparatory period in addition to the period of execution of the project and carry out the exchange of personnel in order to bring international cooperation to a success in a short period of time. The experience with joint actions aboard a drilling vessel and at forums between Japan and France--both are regular members of the International Ocean Drilling Program--proved very useful. Agreement was reached on the execution of this project between the two governments at the sixth meeting held in Paris in 1982 of the Franco-Japanese Scientific and Technological Cooperation Mixed Committee, and the Steering Committee, which has met eight times (the committee meets twice a year) has been in charge of the operation of the project ever since.

2. Results of Kaiko Project

This project was carried out in two stages: In the initial year (1984) precise surveys of the topography of the seabed and underground tectonics were conducted by Jean (Chalcot). In the second year (1985) submerged surveys were conducted 27 times by the Nautile, a new submarine survey vessel. In this year, all results of these surveys are being consolidated.

With respect to the Japanese organizations that participated in this project, the Ocean Research Institute of Tokyo University took charge of the implementation of the project, which was financed by the Ministry of Education, and researchers came from universities and research institutions across the country, including the Hydrographic Department of Maritime Safety Agency, Geological Survey of Japan, Agency of Industrial Science and Technology, Japan National Oil Corp., and Japan Marine Science and Technology Center. From France, IFREMER (Marine Research and Development Organization of France) took charge of the project with the cooperation of CNRS (Scientific Research Agency) and many researchers participated. The activities of young French graduate school researchers captured public attention.

During the surveys conducted by Jean (Chalcot) in the initial year, the multinarrow beam echo sounder mounted on the same vessel proved efficient in drawing detailed topographical charts of the Japan Trench area, but the importance did not lie in the topographical measurement of a specified area alone. Rather, of greater significance was the fact that researchers aboard, of both parties, while exchanging views through discussions based on the new data that were coming up one after another, corrected their existing opinions, and drew up schedules as best as possible for the surveys to be conducted in the second year, by giving a new look at the project. Such a successful

result might not have been available had both teams presented to each other the results of surveys conducted separately and independently. This experience has provided an important guideline for future international cooperation.

These topographical charts on the seabed (21 charts drawn on a scale of 1 to 200,000, 32 charts drawn on a scale of 1 to 50,000, and 8 elevations) were published by the Publishing Society of Tokyo University under the title, "Topographies of Trench and Troughs Around Japan."

In the second year, the (Nautile), a brand-new submarine survey vessel capable of submerging 6,000 m, which was carried to Japan aboard the (Nagil), its mother ship, investigated important points from the western end of the Chishima Trench (southeast of Erimo Point) to the eastern part of the Nankai Trough (south of Enshu Sea), by making three separate submarine cruises.

The (Nautile) was easy to operate, had high mobility, and performed delicate operations by operating two manipulators. She sampled rocks and stones, measured the temperature of the mud on the seabed, and brought back seawater in a special pressure container. Beyond that, on finding a measuring instrument thrown in the sea, she carried it in her arms to a given point and then installed it on the seabed by cutting it off from the float by scissors. She succeeded also in disassembling the instrument by taking out pins using the manipulators and reinstalling them in another place. She dived every day (once a day) for a maximum of 11 hours by replacing batteries, an electric source, in succession.

There was an accident in Enshu Sea in which the external part of the mother ship was damaged by a storm caused by a small atmospheric depression. The ship, moored at Shimizu Port, was completely repaired by several engineers by hand in a month so that there was no trouble in continuing the voyage thereafter.

The direct observation from the submarine survey vessel permitted the investigation of the walls of trenches as precisely as geologists survey land outcrops, so that satisfactory results beyond expectations were obtained. The results of these scientific investigations are to be published soon as a special edition of an international scientific journal and participants from Japan, France, and the United States are scheduled to debate them in Tokyo and Shimizu beginning 10 November this year. (A preliminary report was published on page 286 of the May 1986 issue of KAGAKU by Iwanami Shoten and on page 56 of Vol 94 No 7 of CHIGAKU ZASSHI.) Therefore, they will not be referred to in detail in this paper, but they were unique and important to the extent that our opinions on the structure of a trench and the process by which it is formed had to be completely changed.

One of the results which captured public attention was the discovery of a colony of calyptogena soyoae Okutani at Nankai Trough and in the deep region of the Japan Trench. Colonies of shells and annelida that inhabit the bottom of the sea deeper than 2,500 m, were discovered in the hydrothermal zone of the East Pacific Ocean and later in the waters off Oregon and Florida. In Japan, the Shinkai 2000 confirmed their existence off Hatsushima islet in Sagami Bay. Since the Shinkai 2000 can freely approach the colonies of

animals off Hatsushima islet, they are suitable objects of research, but the sea there is shallow.

Under the Kaiko Project a new world record of depth for colonies of marine life was established successively from the depth of 3,830 m at Nankai Trough to 5,961 m in the Japan Trench. Because it is known that calcium carbonate, which forms a shell, easily melts away in the seawater deeper than 4,000 m, good nourishment must be available for them to grow even in that depth.

It was found that the temperature of the soil at the seabed, where colonies of animals were discovered, was higher about 0.5 degrees than that of the environs and contained a high percentage of methane. So, it has been proved that seawater containing methane and sulfur, which oozed out at this point from underground, grew bacteria, a food source for shellfish. While seawater heated by hot magmas gushes out in the East Pacific Ocean, in the place near the axis of a trench having no magma, water contained in a deposit 1-2 km beneath the seabed is thought to be pressed out by the pressure of subsidence and rises through cracks in the seabed.

The existence of a fault cutting First Kashima Seamount in two from east to west was known from the results of sounding by the Hydrographic Department, but Kaiko Project confirmed that this cliff was formed by a normal fault with a length of nearly 100 km reaching the axis of the Japan Trench. The direct observation from the (Nautile) and the analysis of specimens sampled provided evidence that First Kashima Seamount was crowned with 200-400 m thick coral reef limestone of the Cretaceous abilion (about 100 million years ago) and was later split east and west about 1 million years ago (quite recently, judged from the age of the seamount) by dislocating movements on several occasions.

The western part of the seamount body, which slipped down 1,500 m, is now sinking from the Japan Trench under the mainland. Parts of basalt and limestone making the seamount body will break and peel off and attach to the wall on the side of the main island, but for the most part is assumed to sink deep into the mantle in the present state. From the (Nautile) we could personally witness the boundary line between the seamount just sinking and the main island.

3. Abyssal Survey in the Future

The Kaiko Project provided some valuable guidelines for future abyssal investigations. Since the bottom of the sea in a very deep region is undeniably wide, it is necessary in the future to conduct thoroughgoing and precise investigations into some important areas chosen, by employing what new technology is available. When choosing areas on a priority basis, it is acceptable to choose from a suitable place within EEZ of Japan, but it is extremely desirable to conduct comparative studies under the same research themes by setting another standard point in a place as far as possible from Japan (either in the open sea or EEZ of a foreign country). Such a global vision is indispensable for Japan to have when carrying out surveys and research. Special advice is hereby given to avoid "A frog in the EEZ knows nothing of the great ocean." How important it is to investigate a place near a distant

foreign country can be understood, if you think about how good a harvest the French researchers have taken in from the Kaiko Project.

The use of the multinarrow beam echo sounder and submarine survey vessel as was used by the Kaiko Project will become increasingly important as a method of investigation. A sound transponder operable for a long period is also necessary in order to enable an easy reinvestigating of the place where important facts were discovered. The use of a cabled or uncabled, unmanned submarine vessel will also be extremely effective.

Although the object of the survey was limited this time to the surface of the seabed, it is by any means necessary to know about underground structure. Results of the International Ocean Drilling Program (ODP) will have effects on the research in this area. Japan is a regular member of this program, which started in 1984. The United States, France, West Germany, United Kingdom, and Canada are also members, and EEC (jointly invested by 12 countries in West Europe) will soon join this program. The results of surveys to be made on a priority basis for drilling (a seismic profiler, etc. are used) are expected to be extremely useful andthe measuring of physical properties and magnetism inside the hole drilled and seismic observation there will become increasingly important.

Shinkai 2000 Explorations

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 29-33

[Article by Hiroshi Hotta, manager, Ocean Research Department, Marine Science and Technology Center]

[Text] 1. Outline of "Shinkai 2000"

The successive discoveries of hydrothermal deposits by the submarine survey vessels (Alvin) (United States) and (Siana) (France) in the late 1970s at the ocean rise of the East Pacific Ocean, where the bottom of the sea was expanding, caused a worldwide sensation. In Japan, since its completion at the end of October 1981, the Shinkai 2000, a submarine survey vessel of the 2,000-m class, has produced many good results including the verification of the plate tectonic theory, the discovery of colonies of peculiar marine life, etc. by making underwater cruises over 230 times.

The Shinkai 2000 was designed and built as a unit to constitute one system with the Natsushima, an exclusive support mother ship, and is unique in the world in this respect. It is highly appreciated in the world as a model for an efficient submarine survey vessel system.

The Shinkai 2000 carries two pilots and one researcher in its pressure resistant shell that has a diameter of 2.2 m, allowing them to make observation through two observation windows and take pictures with a color TV camera. It is provided with a manipulator, which permits collection of specimens, operation of a water collector, mud collector and marine life catcher, and installation and recovery of a submarine seismometer, etc. The Shinkai 2000,

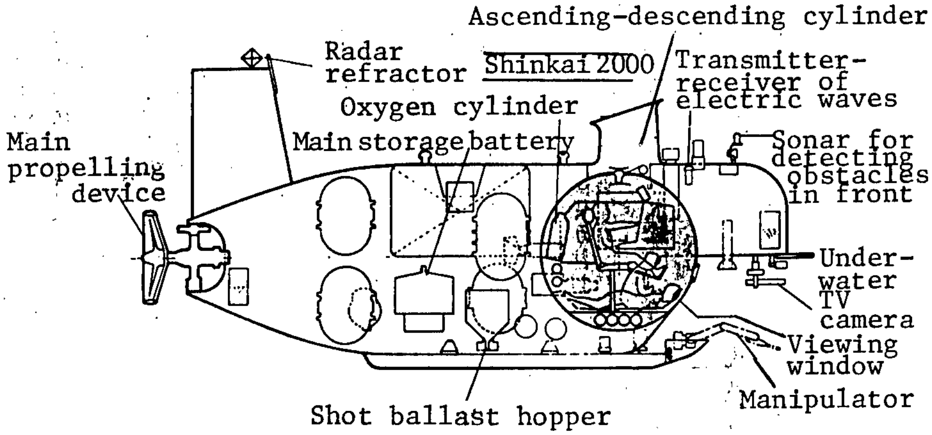

Figure 1. The Shinkai 2000

Main items of Shinkai 2000

• Main dimensions:	Total length:	9.3 m
	Width:	3.02 m
	Height:	2.92 m
	Weight (in air):	23.2 t
• Maximum submergible depth:		2,000 m
• Number of passengers:		3 (2 pilots, 1 observer)
• Underwater speed:	(cruising speed)	about 1 knot
	(maximum speed)	about 3 knots

after it is dropped by its mother ship, can submerge to a seabed 2,000 m deep in about 1.5 hours. During a submarine cruises it can reach a specified point, guided by its mother ship on the surface by the underwater telephone, and make surveys of the seabed for 3-4 hours.

Until now, abyssal investigation was made, in a groping manner, with instruments suspended from a ship on the sea surface. However, it has now become possible for researchers to observe strata, sample rock while verifying with their own eyes, and install a seismometer and other instruments, so marine research is expected to make great strides. Also, in the investigation of marine life the existing method using trawls enabled researchers to obtain only dead specimens, making it difficult to examine the relationship between environment and marine life. So, much is expected from submarine investigation that permits them to observe precisely and grasp their living environment and conditions.

Under these circumstances, a number of applications for embarkation were filed annually. They were, however, screened by the national committee to allow about 60 voyages a year.

2. Results Obtained So Far

2.1 Suruga Bay

As a result of submarine investigations by the Shinkai 2000 in the northern part of Suruga Bay, where the subsidence of the plate was not necessarily clear until this time, the typical structure of the stratum was confirmed. It was confirmed that the west side of the trough protruded developing an abnormal fault because the deposit was pushed to the west side of the trough by the movements of the plate. Its striking similarity to the landform and geological features of the place near the active fault existing along the Fuji River presented important evidence supporting the theory of the subsidence of the plate ranges along the Fuji River.

In the field of marine life, two unique experiments were carried out on the seabed; the degree of marine life activity was measured by dispersing glass powder at the seabed and the speed of extinction due to food poisoning was also measured by leaving dead fish there. As a result, it was discovered that abyssal fauna, which was presumed to have an extremely low metabolic rate compared with the fauna in shallow water, was unexpectedly active. Valuable data were also made available for making a model for marine life production and the data are expected to contribute greatly to the clarification of an abyssal ecosystem.

2.2 Sagami Bay

Since a marine ecosystem is nourished with organic compounds such as plankton originating from optical synthesis, the quantity of marine life distributed in a very deep region beyond the reach of the solar light is very small due to the scarcity of food. However, a special ecosystem nourished with bacteria, which eat methane and inorganic compounds such as hydrogen sulfide supplied from underground, exists in special places such as an outlet emitting thermal water.

The Shinkai 2000 discovered for the first time in Japan colonies of calyptogena soyoae Okutani at Hatsushima islet in Sagami Bay in 1984, and during investigative submarine cruises in 1985 the possibility was pointed out that the existence of these colonies has something to do with the movements of the plate in this region. Later, the (Nautile) discovered small colonies of these shells at Nankai Trough and the Japan Trench during the Kaiko Project. It was also discovered in April of this year during the investigations using the underwater towing camera system of the Kaiko, an experimental vessel for underwater operations, that colonies of these shells were distributed from north to south on the east of Izu Peninsula over a distance of more than 7 km nearly along the active fault presumed to exist in the same region of the sea and that one of the colonies was very large having a diameter of 2-30 m. Live colonies tended to be found in the north and dead ones in the south, and its relationship with the time of activity of the fault is a matter of public interest.

Also, the existence of tube worms similar to those which were discovered at the hydrothermal deposit of Galapagos Ridge in the East Pacific Ocean, was

confirmed. It has recently become clear that their life is maintained by sulfide bacteria living in their tubes in symbiosis and they are completely new animals not belonging to any cagetory. Their existence on the west side of the Pacific Ocean is also arousing great concern.

Furthermore, pillow-shaped lava belts were discovered for the first time in the peripheral waters of Japan during the submarine investigations conducted in 1985. Later during towed cruises a broad range of distribution of lava was found extending to a length of 10 km. Attention is paid to the origin of this lava belt in relation to the movements of the plate.

2.3 Yamato Tai

The origin of Yamato Tai (Japanese bank) located in the center of the Japan Sea has long been the subject of controversy. The terrestrial rock, which was sampled by dredger from the sea surface, did not provide decisive evidence, since there is the possibility that the rock was carried from Siberia during the Ice Age, heaped up and then left protruding.

A landform eroded by waves, known as a pothole, was discovered during the submarine cruises in August 1985 and it was confirmed that the terrestrial rock originated there exactly. As a result, it has become definite that Yamato Tai was originally a part of the Japanese Islands and the Chinese Continent, but separated and subsided due to the expansion of the Japan Sea.

2.4 Other Sea Areas

Other than the above, investigations were conducted on Okinawa Trough, where a hydrothermal phenomenon was expected to exist, Kikai Caldera, the world's largest seabed caldera, and the sea off Sanriku District, where the production of organisms is active. Additionally, a variety of investigative methods were the subjects of experiments, including the measuring of specific gravity at the seabed, on-the-spot experimentation on the activity of marine life, and the survey of under-seabed tectonics by using a subbottom profiler which is for use by a submarine survey vessel.

3. Start of Comprehensive Investigations and Research

Under the new 5-year plan that began in this fiscal year, investigations were to be conducted by the Shinkai 2000 in accordance with the following guidelines, by making most of the experience acquired so far:

3.1 The sea areas to be surveyed are limited to the following four areas, taking into account that the Shinkai 2000 is effective in surveying the steep slopes of a submarine volcano and seismic fault, etc. and that the need for the research on earthquake prediction and the survey of submarine mineral resources are urgent:

(1) Suruga Bay, Sagami Bay, and their peripheral areas which are important for the research on earthquake prediction.

(2) The sea areas surrounding Izu Islands and Ogasawara Islands which are important for research on hydrothermal phenomena, manganese nodules, and manganese crusts.

(3) The sea areas surrounding Nansei Islands where hydrothermal phenomena are expected to exist.

(4) The Japan Sea where the possibility of the subsidence of the plate is indicated and which has special characteristics in the production of marine life.

3.2 Since it is necessary to carry out investigations organically in the above-mentioned areas with the cooperation of as many researchers as possible in order to improve the efficiency of submarine surveys, it is planned to allot a portion of the work to each for every survey trip and ensure mutual utilization of data and specimens obtained. Importance is attached to the following themes for comprehensive investigations and research:

(1) Comprehensive Research in Bordering Areas of Plates

Plate tectonics is elucidated synthetically by investigating the subsidence of plates from the viewpoint of earth science, the distribution of colonies of marine life which provides indexes, and by investigating accumulating, and eroding actions.

(2) Comprehensive Research in Areas of Submarine Volcanos and Seamounts

The process of formation of mineral deposits accompanying hydrothermal phenomena is clarified. The relationship between environmental factors and ecosystems and the quality of manganese nodules and manganese crusts is also clarified.

(3) Comprehensive Research Concerning Bathybic Organisms and the Environment of the Seabed

Bathybic ecosystems are clarified through the investigation of the distribution of marine life, on-the-spot experiments on the metabolism of marine life at the bottom of the sea, and investigation of the relationship between marine life and the environment at the seabed.

(4) Establishment of Standard Regions for Abyssal Investigations and Research

Long-term investigation and research are carried out on crystal movements and ecosystems by accumulating data systematically on Sagami Bay and Suruga Bay and at the same time by setting up standard observation points at the bottom of the sea where seabed faults and colonies of marine life exist.

Table 1. Sea Areas for Immediate Surveys by the Shinkai 2000 and Themes of Comprehensive Surveys and Research

Survey and Research Themes

Survey and research concerning the bordering area of a plate

Suruga Bay, Sagami Bay, and their peripheral sea areas (Senshu Ridge included)

Investigations of microrelief topographies due to crustal movements incident to the subsidence of plates of Suruga and Sagami Troughs and geological features. Investigations of colonies of calyptogena soyoae Okutani, etc. Research into the relationship between piling and eroding actions, the pillow-type lava situated east of the Izu Peninsula and the movements of plates. Surveys of faults in relation to Izu earthquake swarms.

Sea area of Nansei Islands

Surveys of seismic faults incident to an active insular arc and slide faults (the origin of great Showa tidal wave) at the slant of Ryukyu Trench.

Japan Sea

Research into the relationship between the sea area off Toyama Bay, Itouo River, and Fossa Magna. Surveys of the existence of the subsidence of plates and a colony of organisms at the east rim of the Japan Sea. Surveys of the central area of the earthquake in the central part of the Japan Sea. Research on the formative factors of Yamato Tai. Research on piling and eroding actions at Toyama Bay (to make a comparison with Suruga and Sagami Troughs).

Others

The Pacific side of Hokkaido.

Surveys and research concerning the areas of a submarine volcano and seamount

Sea areas of Izu and Ogasawara Islands (peripheral area of Minami Torishima Island included)

Research on the formative mode of a submarine volcano. Investigations of hydrothermal phenomena (hydrothermal ferromanganese oxides at the Kuroshio current crater and hydrothermal manganese oxides at seamounts) and a colony of organisms. Research on the relationship between the ingredients of a manganese nodule and crust and physical, chemical, and biological environmental factors.

Sea area of Nansei Islands

Research on the formative mode of a submarine volcano and investigations of hydrothermal phenomena (around Okinawa Trough) and a colony of organisms.

Others

The Pacific side of Hokkaido.

[continued]

[Continuation of Table 1]

Survey and Research Themes

Surveys and research concerning abyssal fauna and the environment at the bottom of the sea.

Suruga Bay, Sagami Bay, and their peripheral sea areas (Senshu Ridge included)

Investigations of the bank at Sagami sea knoll, the bioecological distribution of organisms at the topography of a sea knoll, deposits, and oceanophysical and chemical environments. On-the-spot experimentation on the activity of organisms. Investigations of the ecosystem of a colony of organisms. The sampling of microorganisms. Comparative studies of organisms and environments at the slant on both sides of a trough.

Sea areas of Izu and Ogasawara Islands (peripheral area of Minami Torishima Island included)

Investigations of bioecological distribution of organisms, deposits, and oceanophysical and chemical environments at the interference area of the Kuroshio current and the topography of a ridge. Comparative studies of organisms and environment on the side of the Shikoku ocean basin and on the side of the northwest Pacific Ocean basin. Investigations of ecosystems in a caldera.

Sea area of Nansei Islands

Investigations of the bioecological distribution of organisms, deposits, and oceanophysical and chemical environments at the tropical low-oxygen area near the origin of Kuroshio current (comparative studies with Izu, Ogasawara, and the Japan Sea).

Japan Sea

Investigations of secular termoclines and the bioecological distribution of organisms incident to a closed sea area. Investigations of the bioecological distribution of organisms, deposits, and oceanophysical and chemical environments at the topographies of a bank such as Yamato Tai and ridge and at the center of an earthquake such as the earthquake in the central part of the Japan Sea.

Others

The Pacific side of Hokkaido.

The establishment of standard sea areas for abyssal investigations

Suruga Bay, Sagami Bay, and their peripheral sea areas (Senshu Ridge included)

Research on the technologies for establishing standard points at the seabed and installing and recovering a seabed inclinometer, etc. The culture of microorganisms and the observation of landslides. The long-term observation of the formation of a ripple mark and the laminar flow at

[continued]

[Continuation of Table 1]

Survey and Research Themes

[Continued]
The establishment of standard sea areas for abyssal investigations

[Continued] Suruga Bay, Sagami Bay, and their peripheral sea areas (Senshu Ridge included)

at the bottom of the sea. Underwater acoustic experiments. Research on object-searching technology.

Sea areas of Izu and Ogasawara Islands (peripheral areas of Minami Torishima Island included)

The establishment of standard sea areas is limited to Suruga Bay and Sagami Bay for the time being, but will be expanded to other sea areas as occasion demands.

Sea area of Nansei Islands

Same as above.

Japan Sea

Same as above.

Others

Same as above

Others

Suruga Bay, Sagami Bay, and their peripheral sea areas (Senshu Ridge included)

Deal flexibly with international demands, urgent tasks, the occurrence of needs in the private sector, and the advancement of research studies.

Sea areas of Izu and Ogasawara Islands (peripheral areas of Minami Torishima Island included)

Same as above.

Sea area of Nansei Islands

Same as above.

Japan Sea

Same as above.

Others

Same as above.

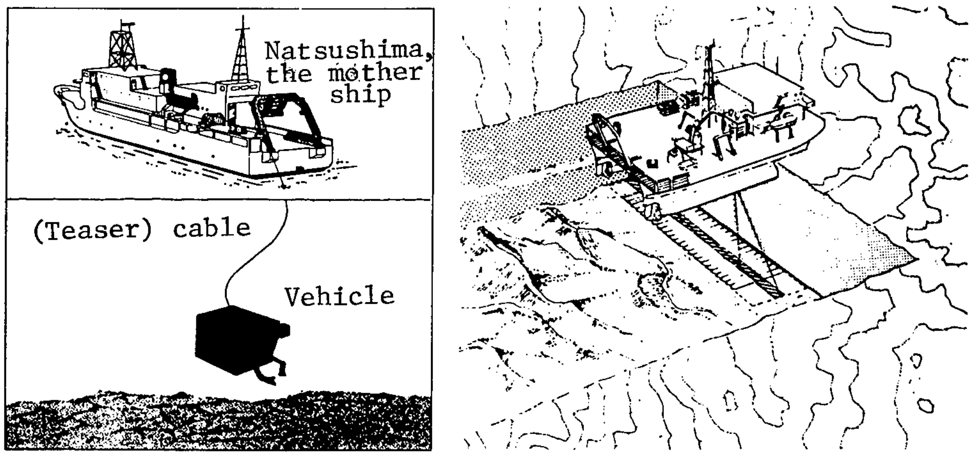

Figure 2. Dolphin 3K, Unmanned Explorer Scheduled To Be Completed at End of FY 1986 (left), Equipped With Sonic Depth Finder (right)

Comprehensive research has already been launched at Sagami Bay in May 1986 by Japan Marine Science and Technology Center taking the initiative, with the National Research Center for Disaster Prevention, the Ocean Research Institute and the Earthquake Research Institute of Tokyo University, and the Institute for Hydrosphere Science of Nagoya University participating. This will be followed by the next investigation program to be implemented in this fiscal year in sea regions including Okinawa Trough, Suruga Bay, the area in the Japan Sea that suffered the aftershock of the Chubu earthquake, Yamato Tai, and Izu and Ogasawara Islands.

4. Establishment of Effective Abyssal Investigation System

Simultaneously with the launching of the Shinkai 2000, Japan Marine Science and Technology Center conducted preliminary surveys by the tow-type side scan sonar and color TV camera mounted on the Natsushima to ensure the efficiency of investigation by the Shinkai 2000 and the safety of her voyage.

At the beginning of the operation of the Shinkai 2000, submarine research cruises were carried out based on the research data accumulated so far by all research institutions concerned over a long period of time. However, the importance of preliminary investigations by the center has increased lately, because submarine trips to the points, where slide cliffs, fault scarps, lava zones, colonies of marine life, etc. which cannot be discovered without employing tow-type systems, have come to be widely required.

Later, at the end of May 1985, the Kaiyo, an experimental vessel for submarine operations equipped with the "sea beam," the newest and most powerful multi-narrow beam sonic depth finder, was completed, which consequently enabled the rapid drawing of more precise topographical maps on the seabed. As a result, it has become possible to conduct towed surveys more efficiently by selecting characteristic landforms. The achievements mentioned in Chapter 2 are owed to the synthetic operation of these systems.

In the future, investigations will be started under the new 5-year plan in the sea areas under the themes, both specified on a priority basis. Furthermore, the Dolphine 3, an unmanned explorer, which will be used in preliminary surveys by the Shinkai 2000 and for rescue, is scheduled to be completed toward the end of 1986. Thus, a great leap is expected in the aspects of both technology and operation concerning submarine research.

Submarine Construction

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 34-38

[Article by Tamotsu Shinohara, manager, Department of Abyssal Development Technology, Japan Marine Science and Technology Center: "Construction of Submarine Survey Vessel of 6,000-m Class"]

[Text] 1. Necessity of Abyssal Investigations

Japan is uniquely positioned in the world as the sole advanced country destined to be submitted to the fate of a typical insular arc--a typical trench system. This is to say, Japan repeatedly has suffered damage from great earthquakes and tidal waves in connection with the subsidence of the plates at the Japan Trench and Nankai Trough, etc.

The hydrothermal deposits (Okinawa Trough, waters surrounding Izu and Ogasawara Islands, etc. with the depth of 2,000-4,000 m), which are expected to exist within Japan's 200-mile waters, are also closely connected with the tectonics of the insular arc/trench system. The crust (1,000-3,000 m) rich in cobalt manganese, which is believed to exist in the peripheral area of Marcus Island, was carried to the vicinity of Japan by a seamount which was moved by the movements of the Pacific Ocean plate.

With regard to biological aspects, colonies of peculiar organisms independent of solar light were discovered one after another in the areas surrounding the outlets of thermal water and in the bordering regions of the plates of troughs and trenches. These organisms came to public attention as indexes for research on ecosystems, hydrothermal phenomena, and crustal movements. Also, these places are attracting attention as a site for the study of bathybic microorganisms.

Outside the 200-mile economic waters of Japan, centering around the so-called "Manganese Ginza" east of Hawaii, manganese nodules superior both qualitatively and quantitatively are distributed at a depth of 6,000 m. Regarding them as a common natural resource for mankind, a mine lot will be allocated for Japan.

It is not going too far to say that Japan is charged with a mission to carry out abyssal research because of its special geographical conditions and great expectations for submarine mineral resources due to its poor natural resources. The necessity for a submarine survey vessel of the 6,000-m class capable of meeting almost all needs arising from oceanological investigations, has often been pointed out since the report of the Marine Science and Technology Council (now called the Council for Ocean Development) was presented in 1979.

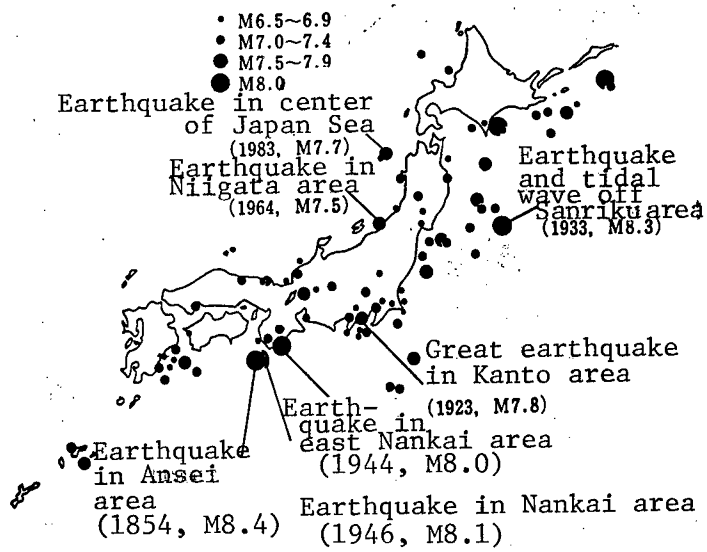

Figure 1. Main Earthquake Occurrences

Later, as an intermediate step in terms of technology, the Shinkai 2000 was built in 1980, and has subsequently produced valuable research into the technology of shipbuilding and operation, and bathybic research studies. However, it can cover only about 30 percent of Japan's 200-mile waters.

Circumstances being as above, the building of a submarine research vessel of the 6,000-m class, the third to be built in the world following the Sea Cliff (United States) and the (Nautile) (France), will be started in this fiscal year and completed in FY 1989.

2. Greatest Submergible Depth

Although the actual conditions inside trenches deeper than 6,000-m are unknown, they were recently clarified in part by investigations made from the sea surface by the Takuyo, a marine survey ship (Maritime Safety Agency) and the Jean (Chalcot) (France); there were a number of big faults and degraded landforms inside these trenches and there were also huge craters (7,000-8,500 m) near three important trenches--the Japan Trench, the Izu-Ogasawara Trench, and the Sagami Trough. These findings provided important data for reinforcing the plate tectonics theory, a key to the clarification of the origin of huge earthquakes.

There are limits, however, to the investigations from the sea surface in understanding these peculiar landforms. The (Nautile) (France), a submarine research vessel that came to Japan in 1985 to participate in the Kaiko Project, failed to survey these interesting points because its maximum submergible depth is 6,000 m. Therefore, a number of people concerned requested that the planned submarine research vessel of Japan of the 6,000-m class have capacity beyond 6,000 m.

Because the Pacific Ocean Plate was bent violently at the Japan Trench in particular when sinking under the Japanese Islands, huge faults were created frequently at the places with the greatest curvature at a depth of about 6,000-6,500 m, and carried intact to the trench bottom just as by an escalator. "Meiji Sanriku Tsunami" (1896, a death toll of 26,360) and "Showa Sanriku Tsunami" (1933, a death toll of 2,995) are considered to have originated from this area.

Waters 6,500-m deep encompass Erimo Seamount, which is broken in half and sinking toward the bottom of the Japan Trench. These same deep waters cover the whole of the First Kashima Seamount (the depth at its foot is 6,000-6,500 m) and the place where an ancient stratum is exposed due to the large-scale collapse of a slope on the landward side of the Japan Trench. A submarine research vessel with a greater submerging capability, if built, will be able to cover the whole area outside the Japan Trench in addition to the above-mentioned areas.

A substantial increase in the maximum submergibility of the planned submarine research vessel in compliance with such a strong demand caused a fear that the efficiency of investigations might be reduced because landing and lifting operations would become more difficult due to increases in the weight and dimensions of the hull, and ascending and descending might take more time. Also, the pressure resistance of its acoustic communication equipment and outfit was brought into question. However, since the use of a pressure-resistant shell made of a titanic alloy to reduce the weight and substantial increases in ascending and descending speed through the change of the vessel's style became feasible as a result of careful examination, it became apparent that a vessel able to submerge to a depth of 6,500 m could be built without affecting its efficiency adversely. In consequence, the maximum depth for the submarine research vessel of the 6,000-m class has been set at 6,500 m, the greatest submergibility in the world among submarine research vessels in active service. So, it would become possible to cover about 96 percent (about 94 percent in the case of a depth of 6,000 m) of the 200 miles of Japanese waters by this vessel.

3. Measures To Make Submarine Vessels More Compact and Lighter

With the maximum depth becoming more than three times that of the Shinkai 2000, in order to keep the weight and dimensions of the hull at the level of the Shinkai 2000 in consideration of landing, lifting, and underwater mobility, new technologies were adopted as follows.

3.1 Pressure-Resistant Shell

The technology for manufacturing a titanium alloy (Ti-6Al-8CoEL1), a material that can be used on a large scale, and a pressure-resistant shell using this titanium alloy were developed in Japan. New production methods such as electron-beam welding and three-dimensional mechanical processing have been developed for building an abyssal submarine vessel for the first time in the world, making it feasible to keep its true sphericity under 1.01 compared with the 1.07 of the Shinkai 2000. Pressure tests were repeated 1,500 times

Table 1. Main Items of Submarine Survey Vessels of 6,000-m Class of Japan, the United States, and France

Name of vessel / Main items	Submarine survey vessel of 6,000-m class	Shinkai 2000	Sea Cliff (United States)	(Nautile) (France)
Maximum submergible depth	6,500 m	2,000 m	6,100 m	6,000 m
Main dimensions Total length Width Height	 About 9.5 m About 2.7 m About 3.2 m	 9.3 m 3.0 m 2.9 m	 9.6 m 3.23 m 3.66 m	 8.0 m 2.7 m 3.45 m
Weight in air	About 25 t	23.2 t	26.3 t	18.5 t
Number of passengers	3	3	3	3
Maximum underwater speed	About 2.5 kt	About 3 kt	2.5 kt	2.5 kt
Life support	More than 81 hours	80 hours	32 hours	120 hours
Diameter of pressure-resistant shell	2,000 mm	2,200 mm	1,980 mm	2,100 mm

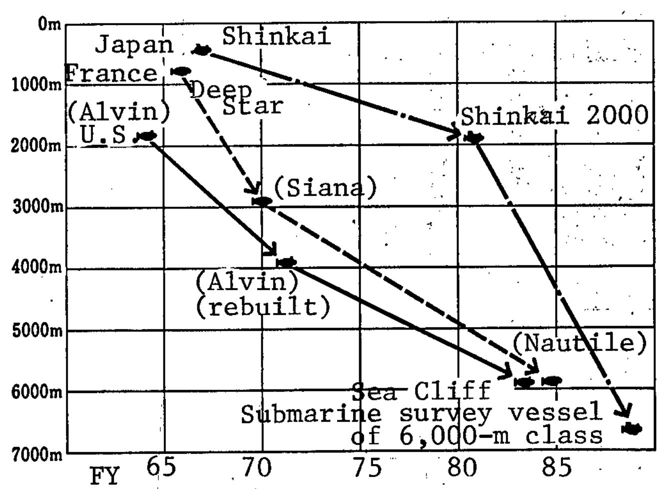

Figure 3. Status of Development of Deep-Sea Submarine Survey Vessels in Leading Countries

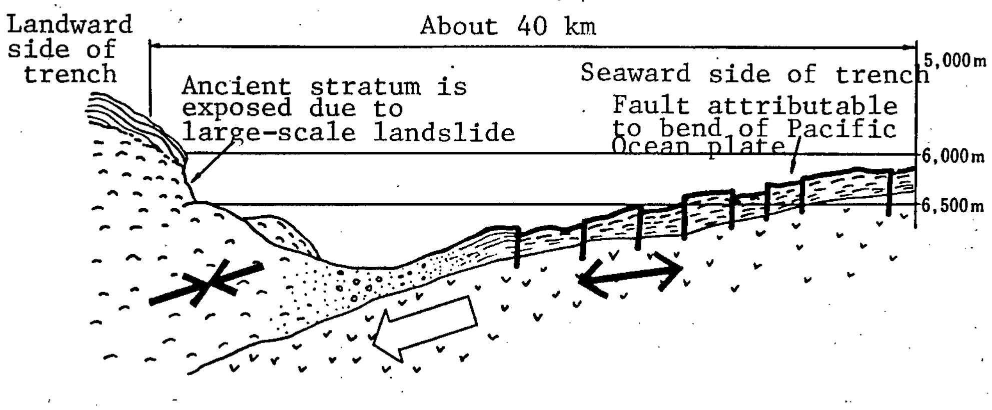

Figure 4. Type Chart of Japan Trench (off Sendai)

at a depth of up to 6,500 m on the scale model with a titanium alloy pressure-resistant shell in the high-pressure experimental water tank of Marine Science and Technology Center in February of this year and the safety of the bathy-vessel was proved.

Other new devices were worked out; navigation information, for example, was centralized on a CRT display to make the steering console smaller in order to reduce the internal diameter of the bathy-vessel's pressure resistant shell to 2 m, compared with the 2.2 m of the Shinkai 2000.

3.2 Buoyant Materials

The submarine research vessels known as a bathyscaphe like the (Alcimade) (France) and the (Trieste) (United States) which used a large amount of gasoline as a buoyant material, have all been retired because the invention of syntactic foam, a synthetic resin, in which hollow glass balls called microballoons are formed, has caused a revolutionary development to submarine research vessels. The submarine research vessel of the 6,000-m class succeeded in increasing the intensity of the buoyant material while keeping almost the same specific gravity of 0.54 as the buoyant material for the Shinkai 2000 by adopting binary-type synthetic foam, in which the space between microballoons is effectively filled with smaller microballoons.

3.3 Others

The development of a transistor and condenser usable in high-pressure oil made it possible to achieve remarkable reductions in weight by changing the inverter (DC/AC converter), which was housed previously in the pressure resistant container, to the oil soaked even-pressure type.

Increases in the depth of submergence imply not only increases in resistance to pressure, but increases in the distance from the sea surface to the seabed. The Shinkai 2000 takes 1.5 hours to descend 2,000 m to the seabed and at this speed would require more than 9 hours for one round trip to and from

the seabed 6,500 m deep. So, steps have been taken to improve the style of the vessel in order to nearly double the ascending and descending speed and as a result it became feasible to secure 3 hours for investigations at the seabed, the same as the Shinkai 2000.

Simultaneously, the increased depth of submergence demands substantial improvements on the acoustic navigation devices and underwater communication equipment. Since it is reported that the Sea Cliff (United States) and the (Nautile) (France) often encountered difficulties in finding positions in the sea and maintaining underwater communication, new systems incorporating the latest technologies are planned for the Japanese submarine research vessel of the 6,000-m class.

4. Improvements Based on Operational Experience With the Shinkai 2000

In addition, operational experience with the Shinkai 2000 since 1981 and opinions of researchers who have been aboard the Nautile and other vessels, are used in various ways. Since it was known from experience that there is a great need for conducting submerged investigations on steep slopes such as a fault scarp and submarine volcano, the following improvements were given as an example, allowing for a substantial improvement in steerability in cruising around complicated landforms of the seabed:

(1) Protrusions were eliminated as much as possible. For example, the auxiliary thruster used for ascending, descending, lateral movements, and turning bows can be folded up into the duct of the hull.

(2) The system in the Shinkai 2000 is designed to be steered by the chief pilot, guided by the control console, not by looking at the outside directly through the window. The new submarine survey vessel is arranged with a wide vision-type window allowing the chief pilot to see the window both straight and transversely.

(3) Since the range of observation by the naked eye is limited only to several meters, the vessel is equipped with an underwater image sonar--the first in the world--which allows the observation andexploration of a wider area.

(4) The Shinkai 2000 which has a bow section stretching out, failed to approach steep slopes because of the threat of touching the slanting surfaces, so the projecting part of the bow of the new submarine survey vessel was cut short and at the same time a diagonal upper vision was secured.

In addition, the new vessel is going to be equipped with a power-sensitive master sleeve-type manipulator, which even the (Nautile) does not have. It is capable of grasping fragile things without breaking and moving with the motion of the passenger's hand, in order to improve greatly its function of collecting rock, etc. at a submarine volcano and fault scarp. The Shinkai 2000 has a defect that when trying to grasp and pull nearer rock with its arm, the hull itself moves, so the new submarine survey vessel is going to have two arms including a grab necessary for fixing the hull and doing complicated work operations.

5. Postscript

As mentioned at the beginning, it is our country's fate and mission to deepen the understanding of abysses and thoroughly pursue the possibility of making most of this knowledge in preventing disaster and developing natural resources.

Scientific Exploration

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 39-41

[Article by Kazuo Kobayashi, professor at Ocean Research Institute of Tokyo University: "What Is Expected of Submarine Survey Vessel of 6,000-m Class in Scientific Aspect"]

[Text] Since the seabed has an average depth of about 3,700 m, and since ocean crusts are 4,753 m deep on the average, much is expected of the new submarine survey vessel that can submerge to the bottom of the sea in a very deep region not reached by Shinkai 2000 to observe directly and investigate the seabed.

In particular, since the new vessel is expected to have sufficient pressure resistance to submerge to a depth of 6,500 m, it is considered extremely valuable to Japan because Japan has the Japan Trench. The seabed east of the Japan Trench in the Pacific Ocean has a depth of a little over 6,000 m and gradually rises near the trench to a depth of 5,800 m. The seabed on the west side of the trench is cut into the form of a terrace by a fault and sinks toward the bottom of the trench, gradually increasing its depth. Each of these fault scarps has a relative height of 300-1,000 m. Since one of these faults is the origin of Sanriku tidal wave in 1933, the investigation is necessary at any cost. Faulting movements are particularly new 30 km east of the axis of the trench at a depth of 6,000-6,500 m.

Since the crust of the seabed in the Pacific Ocean has just been cut by a fault in this place, it may be possible to find exposed chart (siliceous solid rock) and basalt, which form the foundation of the Pacific Ocean, if the search is successful. Even in the place where bedrock is not exposed, a stratified deposit (about 300 m thick), which piled up over a period of more than 100 million years since the Pacific Ocean came into being can be observed directly, so this area is one of the few interesting places for research on the seabed.

1. Difference Between the North and South of the Japan Trench Merits Attention

Since the submerging capacity of the (Nautile), a French submarine survey vessel, was 6,000 m, the place where the normal seabed of Pacific Ocean was cut by a fault, could not be observed, to our regret, in the Kaiko Project. Instead, close surveys were conducted by making submarine cruises 10 times to the Erimo Seamount and the First Kashima Seamount on the northern and southern ends of the Japan Trench. The object of the surveys was to investigate the formation of these seamounts, but at the same time it was also important to observe the faults and sinking places at a reachable depth of 6,000 m by taking advantage of the height of the seamounts.

Since the new submarine survey vessel of the 6,000-m class permits observation of genuine trench walls, its value is great. Because the entire trench bottom is deeper than 7,000 m, even the new vessel cannot reach there. However, because the trench bottom is covered with a new thick deposit, many things cannot be observed as expected. The record of the Archimedes, which submerged there 20 years ago, shows that the deep area of the trench bottom is unexpectedly simple.

Another place we desire to observe at any cost is the slant on the landward side of the Japan Trench. At the slant on the landward side off Hachinohe, the (Nautile) discovered a colony of beautiful calyptogena soyoae Okutani at a depth of 5,901 m by submerging to 5,986 m (both depths are measured by a noncompensating hydraulic depth gauge. A steep cliff where an old terrestrial stratum is exposed, is known to exist about 200 m below. Since metamorphic rock was sampled by a dredge, the ambition is entertained to look directly at the bedrock of the Japanese Archipelago.

Though simply called the "Japan Trench," it is 800 km long. Its aspect differs markedly between north and south. Since only the landward slant north of Japan Trench off Hachinohe could be observed under the Kaiko Project, it is desirous to make submerged observation of the landward slant south of the trench off Joban, too, on completion of thorough and precise examination of the area's designated priority. Because the Japan Trench largely changes its direction off Sendai, a question arises whether there is a difference in tectonics between the north and south of the trench. This is an important question linked with the formative history of the Japanese Archipelago.

2. Repeated Observation of Same Points

Another task the new submarine survey vessel is expected to perform is the repeated observation of the same points. It is, for example, to submerge once a year to the place where the colony of calyptogena soyoae Okutani was discovered by the (Nautile), and observe its changes. Submerged observation every 3 days at the Nankai Trough discovered that both calyptogena soyoae Okutani and sea-cucumbers are immigrant, so it is important to observe their changes 1 or 10 years later from the viewpoints of biology, earth science, and perhaps earthquake prediction. For repeated observation it may be necessary to install a long-term stationary network of acoustic beacons (transponders) that make it possible to submerge to the same place. A system is also necessary in which the unmanned machine, bathycamera, and television other than those which are mounted on the submarine survey vessel, are also equipped with transponders so that they can be used at the same place. Once such a network has been set up, a system can be organized so that monitoring is done at intervals by the unmanned machine and the manned submarine vessel only performs general checks once a year or once every several years for the replacement of the beacons and measuring instruments.

When detecting unusual great changes such as submarine earthquakes and landslides, it is urgently necessary to make a plan, observe the seabed by using the new submarine vessel, and install new measuring instruments such as a seismometer on the most important place of the region in question.

A complete new technique to transfer and install measuring instruments by a submarine survey vessel was developed. The mother ship dropped a measuring instrument fitted with a sink and a bathybuoy near the submarine survey vessel submergence site, which subsequently carried the neutral (the sink and buoy are well balanced in buoyant force) measuring instrument easily (therefore, there is almost no need of a payload) to a given point and installed it at the bottom of the sea by cutting the rope of the buoy by using the scissors of the manipulator.

Additionally, the submarine survey vessel split the measuring instrument into two by pulling out its pins and switched it on and off by turning screws. Furthermore, it succeeded in fixing the measuring instrument with cement (this was dropped after the submergence of the bathyvessel) by making a hole in the sack of cement.

Excellent steerability, rapid motions to perform delicate work, and ease in operating the manipulator are required of the new submarine survey vessel to ensure the satisfactory performance of such submarine operations. It is expected to meet all such requirements.

Since the new vessel of the 6,000-m class will have the opportunity of going out farther than the Shinkai 2000 to perform operations in the open sea, careful attention should be given to its ability to cope with stormy weather. The weather around Japan changes suddenly, so an abrupt weather change can often take place during a submergence that could last for hours. So, it is necessary for the mother ship to be equipped with the ability to evacuate the submarine survey vessel even in fairly rough weather. In an emergency, a step has to be taken either to have the submarine vessel submerge again to wait for the weather to improve or to tow it submerged at a depth of 50 m. The French participants in the Kaiko Project must have fully realized that the peripheral region of Japan is a stormy zone well known in the world.

Great hopes are entertained from activities of Japan's own submarine survey vessel. It is apparent that a number of proposals for scientific cooperation will be coming from both inside and outside Japan. It is desired that Japan be able to conduct fruitful investigations by taking advantage of the international cooperation as much as possible at least from the viewpoint of opening its eyes to the world.

Submarine Survey of Natural Resources

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 41-43

[Article by Kenji Okamura, advisor to Technical Division, Mitsubishi Heavy Industries, Ltd.: "What Is Expected of Submarine Survey Vessel of 6,000-m Class in Aspect of Natural Resources"]

[Text] Since only 3 years have elapsed since the conclusion of the third meeting of the UN Law of the Sea Conference, the law has not yet taken effect. The conference began with an address by Dr (Pardeau), in which he stated that submarine resources are the last property left to mankind, and has lasted over a period of 10 years.

The focus at that time was mainly manganese nodules deposited at the bottom of the sea in deep regions. The nodules are a ferromanganese oxide containing copper, nickel, and cobalt deposited at the surface of the seabed about 5,000 m deep. Although they were first discovered more than 100 years ago, they came to be noticed as a natural resource around 1965. Although they are widely distributed at the seabed, those having the highest economic value exist at the so-called "Manganese Ginza" near latitude 10°N in the Pacific Ocean. Deposits near it alone are estimated to be about 20 billion tons.

Afterward, oceanological studies of the seabed were advanced and hydrothermal deposits and colonies of peculiar organisms inhabiting their peripheral areas were discovered after 1979 on all ocean rises of the East Pacific Ocean. These hydrothermal deposits are comprised of sulfurized minerals which contain a vast volume of copper, lead, zinc, and a number of rare metals. As theorized by plate tectonics, thermal water of a high temperature, which has melted various metallic ingredients, erupts near the expanded axis of the central ridge of the newly created seabed. There it is cooled by cold seawater, precipitates instantly, and heaps up metallic sulfides to form a mineral deposit. It is reported that the United States will conduct a large-scale, 3-month exploratory survey from June to August by employing four survey vessels at a time in addition to the Sea Cliff, a submarine survey vessel of the 6,000-m class, to make assessment of the hydrothermal deposit situated in (Escanaba) Trough of (Golda) Ridge within U.S. waters off the west coast of the North American Continent. The hydrothermal deposits which have been discovered to this date, are all situated near central ridges at a depth of 2,500 m or 3,500 m, approximately. A part of the hydrothermal deposit expanding toward the west of the trench is believed to exist near the place slightly west in the Pacific Ocean where the plate is sinking. Since there are the same signs in the west zone ranging from the Ogasawara Islands to the Mariana Islands, investigation is going to be made from now on.

A third submarine mineral resource known as a cobalt crust has gained attention since 1981. Ferromanganese ores having a high content of cobalt are attached to the foundation like a crust of the wall, not covered in the heap, and surrounding the seamount. They were discovered by the Zonne, a West German marine survey vessel, during the survey of the Line Islands in the Central Pacific Ocean. It was later found that they will be of great value in the future. These ores were discovered at a depth of about 800-2,400 m and are an oxide the same as a manganese nodule. They contain a small quantity, about 1 percent, of copper and cobalt (an ore containing 2.26-percent cobalt at maximum was also discovered) and nickel. It is noted that cobalt crusts contain cobalt three- to five-times more than manganese nodules and the depth of the place where they exist is shallow. Since cobalt is, needless to say, indispensable for new materials technology, it is one of the mineral resources to which increasing importance will be attached in the future. Japan, which depends 100 percent on imports for the supply of cobalt, is anxious about the stable supply due to the notable maldistribution of the countries producing cobalt originating from land. According to the information from oceanological surveys made afterward, a cobalt crust reportedly exists around the seamount situated a little westward from the Central Pacific Ocean and the possibility is high that it also exists within Japan's 200-mile waters.

As mentioned above, it has become known that valuable mineral resources exist on the sea and the role an abyssal survey vessel will play in exploring or developing them is very important. Those which are created locally, the (Alvin) (of the 4,000-m class) and the (Siana) (of the 3,000-m class), but even the Deep Tow and the Angus, tow-type unmanned machines, which were improved over the years, failed to find them. This is a good example to indicate how important the activity of a full-scale abyssal survey vessel is in accompanying the progress in technology. The freedom of movement of a submarine survey vessel coupled with the observation and judgment of a specialized scientist can produce good results in the exploration and development of submarine resources. The United States is mobilizing four submarine vessels in all--the above-mentioned (Alvin) and Sea Cliff plus the Turtle (of the 3,000-m class) and the Princess V (of the 2,400-m class)--for exploring submarine natural resources. France is mobilizing the above-mentioned (Siana) and (Nautile) (the 6,000-m class), which took an active part in the Kaiko Project. Since the Pacific Ocean is regarded as a treasure-house of natural resources, Pacific nations take an interest in it. The construction of Japan's submarine survey vessel of the 6,000-m class promises the possibility of developing mineral resources valuable to Japan, a small country in terms of natural resources, and new drugs by making use of biotechnology developed during the research on bathybic organisms.

Mention was made of the exploration of mineral resources. As the exploration advances into a developmental stage in the future, the submarine survey vessel will play in the survey of the resources in more detail and in the planning, controlling, and expediting of mining operations at the seabed is expected to become greater.

Earthquake Prediction

Tokyo PUROMETEUSU in Japanese Jul-Aug 86 pp 44-45

[Article by Yukio Fujitsuna, Second Research Department, National Research Center for Disaster Prevention: "What Is Expected of Submarine Survey Vessel of 6,000-M Class in Aspect of Earthquake Prediction?"]

[Text] What accelerates development in any field of science is a new idea, a new approach, and the steady accumulation of data. The evolution of a new aspect due to the application of a new technology contributes to substantial development in a given area in that it provides an opportunity to verify directly and concretely the theory and hypothesis presented. Also, observations and experiments by using new technologies provide an opportunity for discovering unexpected facts. That Japan has come at long last to undertake the development of a submarine survey vessel of the 6,000-m class makes my heart fill with expectations as one of the researchers in this field, because it is expected to cause research into the abyssal zone, which has been backward in progress due to technical difficulties, to make great strides both qualitatively and quantitatively.

Research on earthquake prediction in Japan is being carried forward, with the cooperation of organizations concerned, as a national project under an earthquake prediction plan (at present the fifth plan). Earthquake prediction

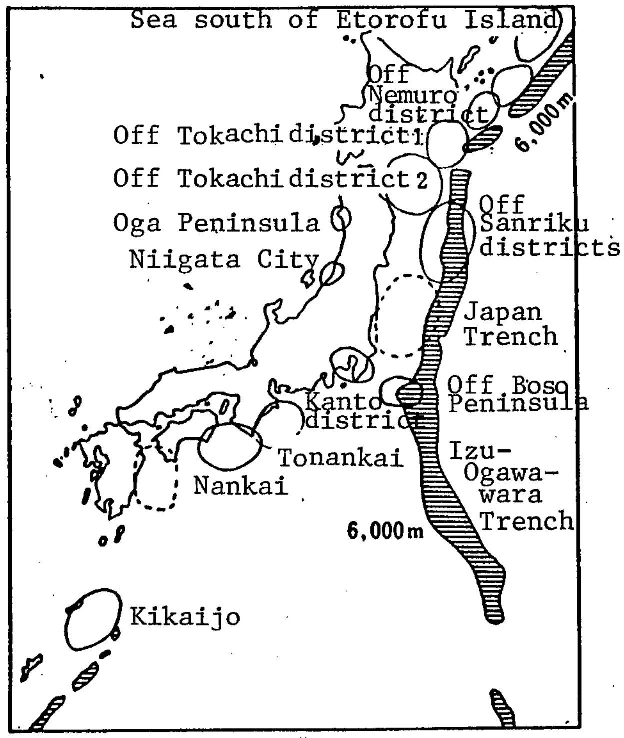

Figure 1. Sea Areas Where Huge Earthquakes Occurred

takes the following four basic steps: 1) a statistical prediction based on the data on seismic activities in the past and active faults; 2) a long-term prediction made by monitoring the accumulation of crustal distortions; 3) a medium- and long-term prediction based on the data on premonitory symptoms of an earthquake; and 4) prediction just prior to the occurrence of an earthquake based on the data on premonitory symptoms shown several hours before the occurrence. The method of predicting a submarine earthquake is based fundamentally on the above-mentioned methodologies. Its only difference from the observation on land is that the observation of a submarine earthquake is markedly difficult to make in many cases, compared with the observation on land due to the conditions of the seabed, where premonitory phenomena are observed, such as high-water pressure. Great strides are expected to be made in effective measuring technology for predicting a submarine earthquake owing to the operation of a submarine survey vessel of the 6,000-m class. The waters around Japan where tremendous earthquakes used to occur, are shown in Figure 1. Also, the waters deeper than 6,000 m are shown by horizontal lines in Figure 1. It is apparent that it will become possible to investigate most of the regions where submarine earthquakes can occur, except the deepest parts of trenches, by the submarine vessel to be developed.

What can be expected in research on earthquake prediction, in relation to the above-mentioned statistical prediction, is the development of the method of investigating active seabed tectonics around the bordering areas of the plates at the bottom of the sea in deep regions. If a method of exploration through the survey of topographies of earthquake faults and geological features has

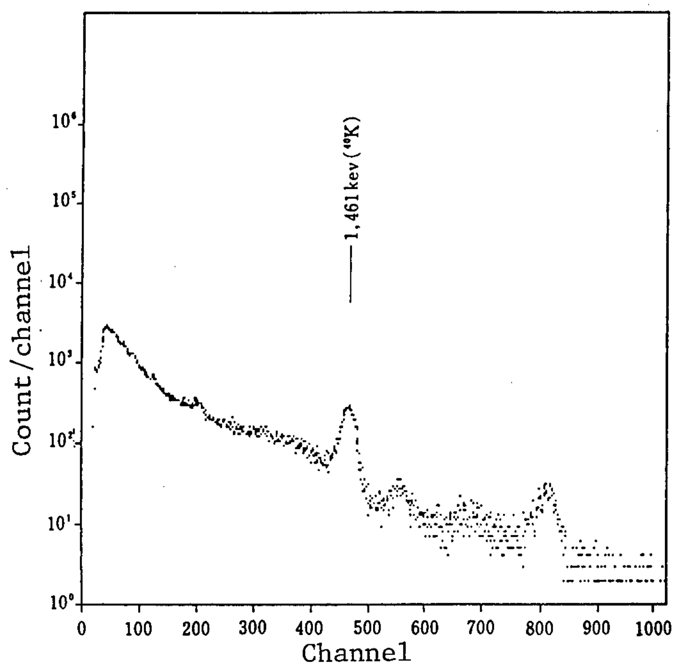

Figure 2. Gamma-Ray Spectrum Measured at Sea Area East of Sagami Sea and Izu Peninsula Where calyptogena soyoae Okutani Inhabit

been established, the time will come when it will become possible to draw the map of active seabed faults close to the level of the map of active land faults already published. The close observation by the naked eye from the Shinkai 2000 of the landforms of the seabed in Suruga Bay made clear those which could not be observed from the sea surface, and provided an important clue to the origin of Suruga Trough. Likewise, the investigation by a submarine survey vessel of the 6,000-m class will greatly expedite the development in this area through the verification of the models presented concerning the tectonic movements of the bordering section of a plate at the bottom of the sea in a deep region and the discovery of new facts. The method of surveying active seabed faults can be an expanded application of the method in practical use on land. In this case, a method using physical measurement is also expected to be developed in parallel with the observation by the naked eye of seabed landforms and colonies of organisms including calyptogena soyoae Okutani. An example of gamma-ray spectrums measured by Norio Yoshida and other researchers of the National Research Center for Disaster Prevention aboard the Shinkai 2000 in this fiscal year is shown in Figure 2. This was measured at the seabed about 1,100-m deep out at the sea east of Ito City where calyptogena soyoae Okutani live, and the spectral intensity of 40 K showed a significant difference, compared with the intensity in an area not inhabited. Despite a number of points still to be examined, the spectral method can be considered promising as a method for surveying active seabed tectonics. The measurement of gamma-rays is one example that permits accurate measuring, since the noise of air radiation, which causes a great problem when measuring on land, is shut out by seawater. Other than the spectral measurement, measuring electromagnetic

waves and high-frequency earthquake vibration and ultimate analysis of the submarine soil are also considered promising as a method for surveying active seabed tectonics.

In the case of measurement on land for the purpose of long-, medium-, and short-term earthquake prediction, it is normal to observe minute premonitory phenomena after the careful examination of the place and method to install measuring instruments. In measuring earthquakes, for example, noise is kept at a minimum by fixing a seismometer on a hard bedrock. Where no exposed rock is available, a well is dug avoiding a soft stratified heap. It occurs sometimes that a 3,000-m deep well is bored, such as the deep-stratum observation well of the National Research Center for Disaster Prevention, which was bored in an area covered with a thick stratified heap to ensure accurate earthquake observation. The inability to apply such a careful method of installing a seismometer to measure the crustal movements at the seabed is one of the reasons the research in this field is behind in progress despite its great importance.

A method of ensuring highly precise measurement in most areas where huge earthquakesoccur is expected to be developed by employing a submarine survey vessel of the 6,000-m class, making it possible to observe the changing movements leading to the occurrence of an earthquake. Therefore, it may be necessary to consider the development of an observational method including measuring instruments in parallel with the development of a survey vessel.

It is hoped that Japan, at the top-level in the world in the research on earthquake prediction, will establish a method of making highly precise predictions of gigantic submarine earthquakes by developing a measuring method for predicting them and contribute to the alleviation of damage in Pacific rim countries suffering from submarine earthquakes.

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COOPERATIVE R&D ACTIVITIES IN CERAMICS DESCRIBED

Government, Industry, University Tie-Ups

Tokyo CERAMICS JAPAN in Japanese Nov 86 pp 1017-1019

[Article by Ikuo Tomita]

[Text] 1. Preface

The promotion of active technical development is a requisite in our nation with limited resources and land. This will enable the nation to surmount such restrictions, retain its economic foundation, and contribute to the international economic society.

In doing so, the government must naturally play an important role. However, as private enterprises have provided approximately 70 percent of the nation's total R&D expenses, completion of environmental conditions to allow them to fully display its vigor in technical development is also urgently required.

Due to technical development of basic and advanced fields rapidly becoming interdisciplinary recently, concentration of the knowledge and technology of many fields has become inevitable. In order to challenge creative technical spheres, the promotion of technical development which maintains mutually organic relations between the respective stages, that is, basic research, application research and development research is also necessary.

Along with these quantitative and qualitative changes in technical development, it is important that the government, industries, and universities supplement each other while maintaining their independence, in addition to technical development by the government alone or by private enterprises.

Under these circumstances, 1985 was a notable year for tie-ups between these three sectors for ceramics related technical development. The Fine Ceramics Center (juridical foundation) was established along with the New Diamond Forum and the New Glass Forum.

2. Technical Development of Fine Ceramics and the Role of the Center

Fine ceramics which are still in the cradle years must forward sound development of its materials and industry by solving existing problems.

While both the government and the people must share appropriate roles and grapple with problems effectively and compositely, based on the present conditions of fine ceramics, its development greatly lies in the hands of the private sector. However, as the activities of private enterprises and private organizations naturally have their restrictions, such as in technical development which is difficult for the private sector to handle alone, the government is expected to play an important role in completing the foundation of the industry which includes a material assessment, testing system, and statistics.

(1) Fine Ceramics Technology Research Association

This association was set up in September 1981 to execute the Fine Ceramics R&D. This is one of the themes of the Research and Development Project of Basic Technologies for Future Industries also established in FY 1981 for the R&D of technologies required as the base for future prospective industries of the 1990's. It consists of 15 firms engaged in materials, manufacture, processing, and application of fine ceramics and intends to establish foundation technology to make use of fine ceramics as industrial structural material.

As part of the Research and Development Project of Basic Technologies for Future Industries, research will be conducted by the National Research Institute and the Fine Ceramics Technology Research Association while receiving advice from various committees. The National Research Institute will mainly take charge of the very basic sectors of molding, processing, sintering, and assessment while the Association takes up other fields.

(2) Japan Fine Ceramics Association (JFCA)

The JFCA was established in July 1982 from a group of fine ceramics related companies.

In order to promote smooth production and application of fine ceramics, it is necessary to fulfill the demands of the parties concerned in material development and application and construct a cooperative relationship. While there is a downstream movement of the material supplying side to take up molding, sintering, and processing to acquire high-value materials and an upstream movement of users to handle molding, sintering, and processing themselves in the search for materials, vertical cooperation between enterprises must be promoted, at times, according to each condition. The role of JFCA is extremely large, as a ground to exchange information in the nation and with overseas nations, to unite the "needs" and "seeds" of technology through exchange of personnel and matching.

In the fall of 1986, the JFCA expects to become an aggregate corporation as an organization of business quarters.

(3) Japan Fine Ceramics Center (JFCC)

In order to promote the usage of fine ceramics, it is necessary to supply reliable data regarding its basic properties for proper designing, in a

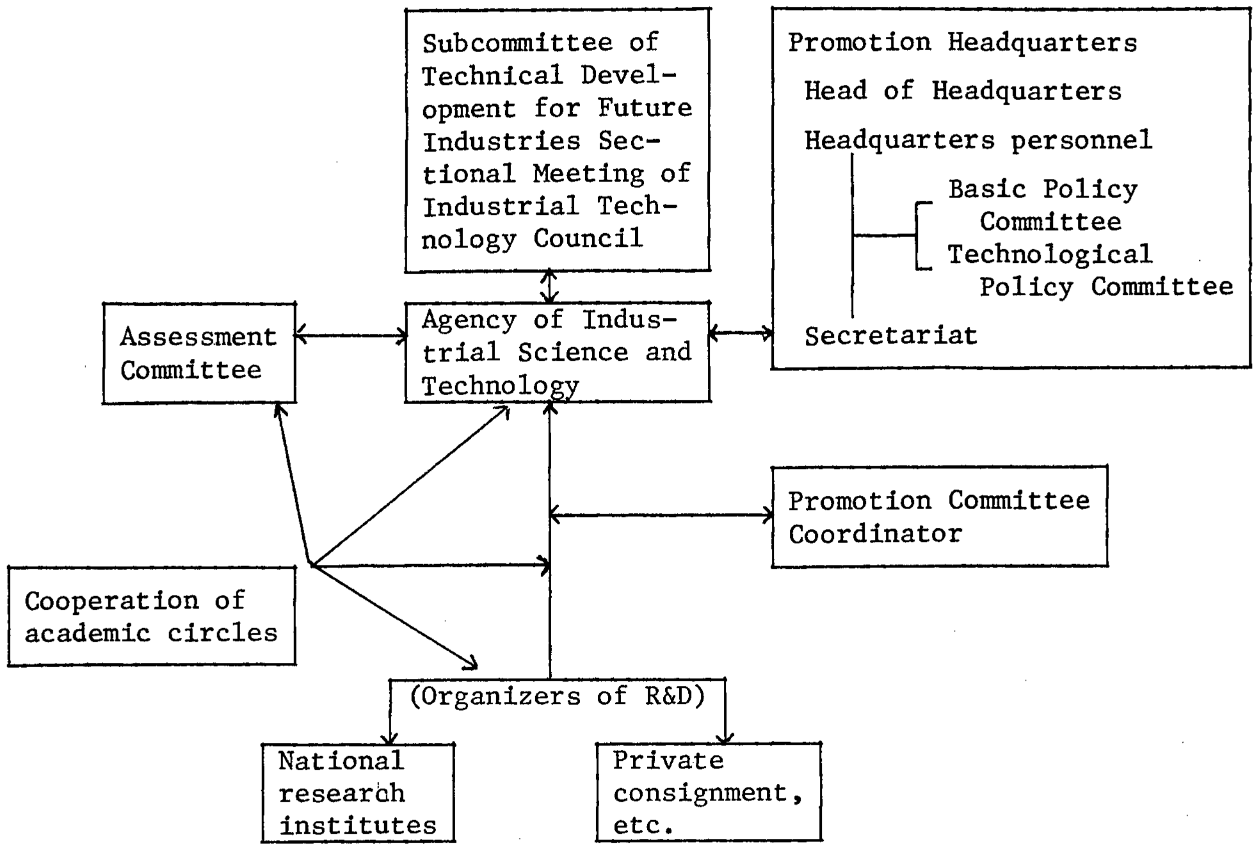

Figure 1. Implementation System of R&D Project of Basic Technologies for Future Industries

Table 1. Organs Implementing Research and Development Project of Basic Technologies for Future Industries

Theme	Major private organ	National Research Institutions
Fine ceramics	Fine Ceramics Technology Association	Government Industrial Research Institute, Osaka; National Chemical Laboratory for Industry; Mechanical Engineering Laboratory; Government Industrial Research Institute, Nagoya; Inorganic Material Properties Research Institute

comparable form with other materials. However, as the presently applied assessment and testing system is still unestablished and incoherent, standardization of the testing method is a pressing problem.

To cope with this problem, the JFCC was set up in Nagoya in May 1985, led by the business circles and self-governing organs of Nagoya. Other main businesses of JFCC include technical guidance for smaller businesses and a window to exchange international technology. The government is actively supporting the organ in consideration of its important role.

(4) New Diamond Forum (NDF)

The NDF was established in July 1985 as an organ to expand and advance the industrial application of new diamonds through technical development of superior diamonds. Information exchange and studies by researchers and technicians of the government, industries, and universities are also conducted to exploit new application fields.

(5) New Glass Forum (NGF)

Glass which has been conventionally used as plate glass, glassware, glass bulbs, etc. is expected to enlarge new usages, such as optical communications fiber, laser radiators, and separate films. Consequently, the NGF was set up in July 1985 for the technical development and practical usage of a new glass which greatly differs from conventional glass in its function, composition, and manufacturing method.

(6) Basic Technology Research Promotion Center

This organ was set up in October 1985 based on the Law for Smooth Research of Basic Technology. It handles the development of basic technology through cooperation between the government, industries, and universities with full use of the private sector.

Its main business includes investment to joint R&D firms, conditional non-interest-bearing financing, mediation of joint research with national research institutes, entrusted testing and research, supply of valuable research information in the possession of governmental organs, and invitations by researchers from abroad for the promotion of basic technology-related test research conducted by the private sector.

The Center has been entrusted with two financing cases of ceramics-related basic technology in FY 1985 and has also consigned surveys from overseas testing and assessment organs to the JFCC.

3. Conclusion

After World War II, Japan achieved rapid economic progress through the import of foreign technology and effective technical development and has grown into the second largest economic giant in the free world.

However, while Japan is considered to be equivalent or superior to Western nations in the development stage, when technical standards are compared, she has few leads in the basic application research fields. Thus, our nation must promote basic and original technical development in order to make progress

while contributing to the world. It is also necessary to forward research while maintaining close cooperation between industries, academic circles, and the government. The various organs mentioned are also expected to further advance to mediate ceramics R&D of the three sectors.

Fine Ceramics Association

Tokyo CERAMIC JAPAN in Japanese Nov 86 pp 1019-1023

[Article by Masatoshi Shiota]

[Text] Fine ceramics is spotlighted from various fields as a very important new material for technical development as well as for the activation and advancement of industries. It is also believed to construct its own new industry in the future.

1. Role of the Fine Ceramics Association

The Fine Ceramics Association (Chairman Shinroku Saito) was set up on 23 July 1982 jointly by producers of raw materials, materials, parts and equipment for fine ceramics, and their users.

The number of member companies which was approximately 100 at the start has doubled to about 200 firms, at present. Its members are as follows:

Regular members (producers, users) 169 firms
Supporting members (trading company, banking business, groups) 27 firms and 3 groups
Special members (scholars and veterans) 5 persons
The businesses of regular members consist of ceramics (46 firms); chemical and textile (38 firms); iron and steel and nonferrous (25 firms); electricity (22 firms); machinery (23 firms); automobile (8 firms); heavy industry and engineering (7 firms).

Accordingly, enterprises from multiple fields have joined in the Fine Ceramics Association for the promotion of fine ceramics related information exchange, diffusion of the material, surveying, standardization, and international cooperation. Meanwhile, the Structural Material Sectional Meeting, Functional Material Sectional Meeting and Precision Processing Sectional Meeting have been set up in order to join personnel from different industries and promote training and mutual exchange of information and opinions across multiple fields.

These diversified enterprises have entered the fine ceramics field and intend to multipolarize technology and advance products with the respective technical potential.

The main motives of enterprises entering the fine ceramics industry are classified by industries in Table 1.

Table 1. Background of Businesses Entering Fine Ceramics Field (by industry)

Industry	Present condition	Basic technology	Countermeasures	Number of members*
Ceramic industry	Waning demand	Ceramics production technology	Sophistication of products Multipolarization of technologies	46
Chemical industry Textile industry	Waning demand	Materials production	Production of fine materials Advancement to downstream fields	38
Iron and steel industry	Waning demand	Similar mate-material manufacturing technology	Independent development by company, joint research	25
Nonferrous metals manufacturing industry	Advancement of process parts material pursued	Application technology	Independent consumption and sales by company	
Electronics/electric machinery and appliance industry	Sophistication of productions, multipolarization pursued (need for material focusing on specified purposes)	Assessment application technology	Independent development by company, joint research Retracing upstream field	22
Transport machinery industry	High efficiency pursued in engines (limit of existing materials)	Assessment application technology	Independent development by company, joint research Self-consumption by company	8
Machinery industry Engineering industry	Higher efficiency of product system pursued (limit of existing materials)	Assessment application technology	Independent development by company, joint research Self-consumption and sales	30

(From meeting report on Fine Ceramics Basic Problems by Ministry of International Trade and Industry, May 1984)
*Number of full members of Fine Ceramics Association

2. Undertakings of Fine Ceramics Association

Since its establishment in 1982, the association has taken up themes with greater urgency and importance, in succession. As such undertakings have turned out favorably, for the most part, it has entered a stage to make itself an aggregate corporation. Taking this occasion, the association is making efforts to expand appealing businesses.

2.1 Information Exchange and Diffusion Activities

(1) Publication of FC Report: A report on the explanation of industrial policies and technologies, introduction of new products and technologies, patent trends, domestic and overseas news, are published every month.

(2) Publication of fine ceramics catalogs: A catalog on raw materials, materials, manufacturing, processing equipment, and measuring and assessment devices has been compiled and published (1984 edition). A revised edition is scheduled to be in print soon.

(3) Cooperating production of Industry Graph "Japan's Fine Ceramics Industry," a small booklet for education and diffusion of fine ceramics.

(4) Opening the "Basic Seminar" for nonspecialists

(5) Collection and supply of information related to the Ministry of International Trade and Industry (MITI).

(6) Others.

2.2 Surveying

Industrial trends, technological trends, and safety and hygienic control related to fine ceramics and industrial measures to internationalize the materials were researched. Research items which were investigated until FY 1984 are as follows:

(1) Survey on technical development trends and development trends of related fine ceramics equipment--Survey on industrial trends of fine ceramics (entrusted in FY 1982).

(2) Survey on development and application of equipment for manufacturing fine ceramics (entrusted in FY 1983).

(3) Survey on technical development trends of ceramic coating and its application in new industrial fields (entrusted in FY 1984).

(4) Survey on industrial measures for fine ceramics (survey classified by respective material and problem).

① Powder material of fine ceramics (entrusted in FY 1984)
② Complex and junctioning technology of fine ceramics (entrusted in FY 1985)

(5) Survey on present conditions of high-temperature, high-strength ceramics (entrusted in FY 1984).

(6) Survey on development and application of bioceramics, etc. (entrusted in FY 1985).

(7) Survey on industrial trends of fine ceramics (conducted independently in FY 1984 and 1985).

(8) Survey on international strategy of fine ceramics industry (conducted independent in FY 1985).

(9) Survey on safety and hygienic control of fine ceramics manufacturing process (entrusted in FY 1985).

2.3 Standardization Activities

The "Investigative Study on Standardization of Fine Ceramics" has been conducted since FY 1983 as a consignment project of the Agency of Industrial Science and Technology.

In respect to structural material, 1) study on the present performance assessment system, domestic and overseas; 2) project planning to promote standardization; and 3) high-temperature flexural tests, tension tests, fracture toughness tests, high-temperature elastic modulus over Poisson ratio tests of the major oxides and nonoxides, and basic data formation for standardization have been conducted.

2.4 International Cooperation Activities

The following activities are forwarded in order to promote international gatherings and cooperation in the fine ceramics field.

(1) Holding and participating in international conferences: The First International Conference of Ceramics for Engines was held in October 1983 for the first time in Japan which received our full cooperation from the standpoint of international exchange. For the second meeting of this conference held in West Germany in April 1986, examiners were sent to follow the development trends of ceramics parts. The Japan-Korea Ceramics Seminar held in Tsukuba Science City in November 1985 was also supported.

(2) Holding special lectures by specialists from abroad: Five to six lectures are held every year by notable foreign specialists visiting Japan.

(3) Publications of FC Annual Report's overseas edition: Articles suitable for the overseas edition are selected from the FC Report, translated into English, and published once a year.

(4) International interchange through industrial cooperation, etc.: To cope with overseas demands, places for industrial cooperation, etc. are supplied.

2.5 Activities of Sectional Meetings

For the interchange of members from multiple fields, the Structural Material, Functional Material, and Precision Processing Sectional Meetings were organized. Activities including the following are executed four times a year.

(1) Supplying introduction of new products and technology from respective companies with topics of discussion (30-35 cases annually).

(2) Lectures and discussions by specialists: Lectures, etc. by learned and experienced personnel and specialists from enterprises (20-25 cases annually).

(3) Field trip: Visit to public laboratories and plants of private enterprises (10-15 cases annually).

(4) Gatherings: Gatherings of members (nine times annually).

The above-mentioned activities of the sectional meetings are regularly conducted as the central business of the association.

3. Industrial Trends and Prospects of Fine Ceramics

As the fine ceramics industry is still in the basic stage, statistical material regarding production and application is not fully provided. A survey on the production movements of fine ceramics conducted by the Survey and Statistics Division of MITI which starts from the business showings of January 1986 is expected to be available as yearly statistics after 1987.

The Fine Ceramics Association has conducted the "Survey on Industrial Trends of Fine Ceramics" which consists of annual questionnaires to enterprises since 1983. Production and application conditions of powder material and members, import and export conditions, and R&D investment of this field have been investigated. The following is a partial introduction of this survey.

3.1 Production Sum of Fine Ceramics Members

The production sum of fine ceramics members (material and parts) according to the FY 1985 survey is shown in Figure 1. The ¥807 billion (actual sum) of FY 1984, ¥829.5 billion (estimate) of FY 1985, and ¥891.1 billion (estimate) of FY 1986 fall slightly below the results of the survey for the previous year. This is considered to be caused by slacking business called semiconductor depression. The electromagnetic members still take up a large share (approximately 75 percent) in the production items.

3.2 Growth of Fine Ceramics-Related R&D Investment

Enterprises are actively promoting technical development of fine ceramics to realize its practical application.

As shown in Figure 2, fine ceramics related R&D personnel and investments are steadily growing each year, which indicates a trend to emphasize R&D.

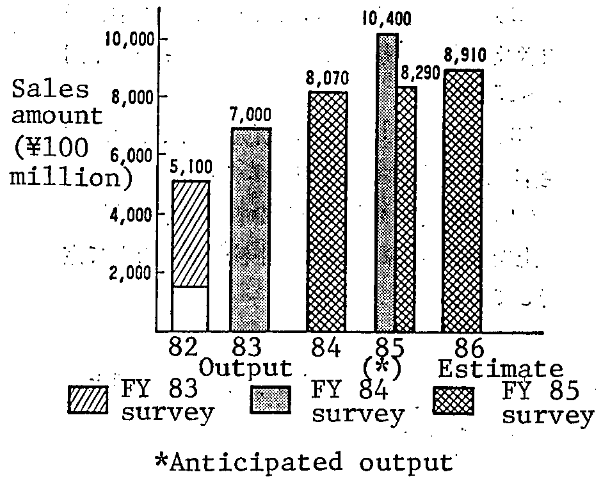

Figure 1. Annual Sales Output of Fine Ceramics Members

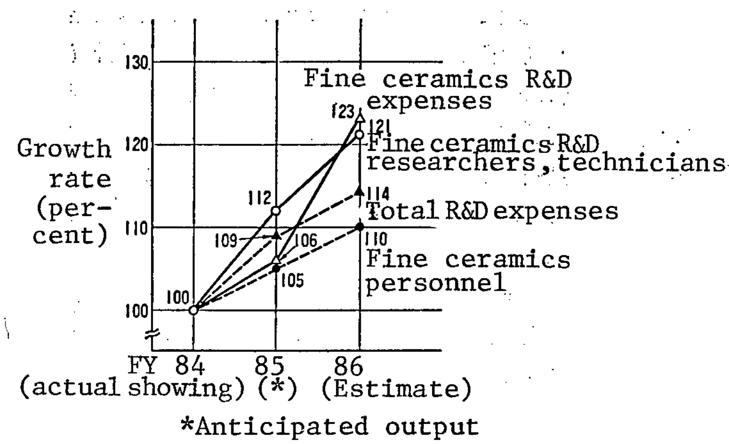

Figure 2. Fine Ceramics-Related R&D Personnel and R&D Expenses

3.3 Future Prospects

The central field in the fine ceramics market is presently the electromagnetic function field which it is believed will grow steadily along with the development of high function ceramics in the future.

Meanwhile, fine ceramics for structural usage which does not have large-scale sales at present, is, however, increasing its investment and facilities for R&D each year and is expected to grow rapidly in a few years.

The "Fine Ceramics Market Scale Forecast," the result of a survey was announced by MITI in May 1984, as an index for future prospects of the fine ceramics market (Figure 3).

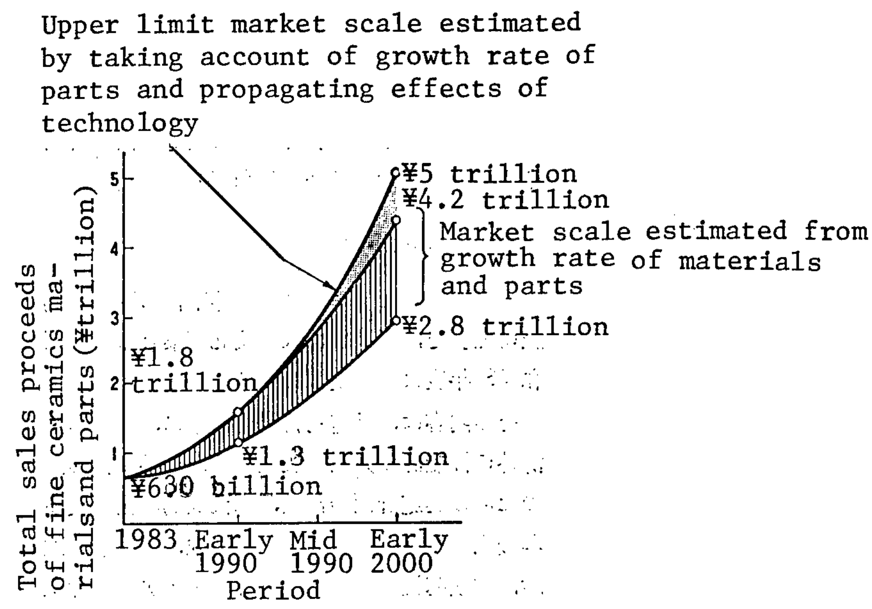

Figure 3. Forecast of Fine Ceramics Market Scale (module base)
(Report of Fine Ceramics Meeting of MITI)

4. Conclusion

Since its establishment in 1983, the Fine Ceramics Association has been promoting various businesses including fine ceramics-related information exchange, its diffusion, surveys on the industry and technology, standardization, and international cooperation. The member companies consist of fine ceramics-related makers and users which have increased to approximately 200.

Enterprises of multiple fields which have advanced into the fine ceramics market are aiming at multipolarization and advancement of technologies using each company's potential.

In order to expand the application of fine ceramics, it is important to unite the related business circles from wideranged fields. The Fine Ceramics Association which will soon become an aggregate corporation is expected to play an important role as the central organ engaged in expanding businesses and advancing the fine ceramics industry.

Activites of Fine Ceramics Center

Tokyo CERAMIC JAPAN in Japanese Nov 86 pp 1023-1026

[Article by Hiroshi Okuda]

[Text] 1. Preface

The Japan Fine Ceramics Center (JFCC) was established in May 1985 in Nagoya City. It is a foundation set up by a national request to complete basic technology of the advanced material technology fields with the cooperation of industries, universities, and the government. It aims at developing fine ceramics-related original technology. Its major undertakings consist of R&D, promotion of standardization and assessment tests, data banking and information service, technical guidance for the establishment of an economic base for smaller businesses, diffusion of correct information related to fine ceramics, and raising personnel.

The JFCC is steadily forwarding activities to become an organ which handles various international cooperatives. It also actively leads our nation's fine ceramics industry and peripheral industries, under the cooperation of universities, laboratories, various organizations, and private enterprises.

2. Organization and Activities of JFCC

The organization of the JFCC is shown in Figure 1 [omitted]. Its laboratory which is its central body consists of four basic research sections for chemical analysis, physical testing assessment, characteristic testing and assessment of structural materials, and development of manufacturing and processing technology, and a project research team. It conducts independent research on basic technology of fine ceramics and also handles entrusted research. Project teams are organized mainly for entrusted research which conduct R&D while closely cooperating with basic research sections. Those in charge of these studies which were started by approximately forty persons are expected to increase to over 100 in 5-10 years.

3. Outline of JFCC's Construction Plan

(1) Construction site: 2-chome Mutsuno, Atsuta-ku Nagoya City

This district is located inthe development region of Atsuta Shrine's eastern district which was improved and regenerated. This area, which is close to the Japanese National Railway, Nagoya Railway, and the subway is very convenient for transportation. It is located in a quiet environment surrounded by green, facing the Jingu Eastern Part at its eastern side.

(2) Site area: approximately 1.8 ha

(3) Outline of construction:

Office management exhibition hall	(two-storied)	approximately 1,697 m^2
Laboratory	(five-storied)	approximately 7,993 m^2
Research and experiment building	(one-storied)	approximately 1,120 m^2
Others, warehouse, etc.		approximately 68 m^2
	Total	approximately 10,878 m^2

Construction of the above buildings was started in October 1985. The research and experiment building is partially completed and the remaining buildings and facilities are expected to be finished by March 1987. The conceptual drawings of the laboratory and the office management exhibition hall are shown in Figure 2 [omitted].

4. Present Activities of JFCC

The JFCC has been forwarding efforts to complete its construction and secure laboratory facilities and personnel, towards full operation scheduled from April 1987. Meanwhile, several undertakings have also been conducted and planned.

One of them is the fine ceramics related education and diffusion activities as the main host organization of the Fine Ceramics Fair and International Forum held simultaneously in March 1986. It has also participated in several new international projects and has partially executed independent research activities. An outline of its undertakings conducted up to the present follows.

4.1 Independent Research

Independent research is conducted on the following subjects in order to complete basic technologies of fine ceramics and expand future application fields.

(1) Development of assessment tests of the mechanical properties of fine ceramics for structural materials.

(2) Survey on standardization of assessment tests of the said mechanical properties, etc.

(3) Research of synthesis and characterization of fine ceramics material powder.

4.2 Entrusted Research

(1) Corroboration test of advanced light water reactor (LWR) revision technology (corrobation test for development of inspection-free facilities):

Entrusted by MITI through the Machinery and Equipment Development Center for Future Industries of the Technological Research Association, the applicability

of fine ceramics in LWR parts which have wearing, corrosion, and radiation problems of cobalt component is studied and aptitudinal assessment technology is developed. Higher reliability, better maintenance, reduction in the number of regular inspection dates, lengthening of the number of continuous operation dates and the reduction in the exposure amount are aimed at by the use of fine ceramics in LWR parts and equipment. In FY 1985, a survey was conducted on the extraction of fine ceramics which could be applied in nuclear power plants. Studies on various assessment tests required to conduct this project and R&D to solve the problems which emerge when applying fine ceramics have also been forwarded.

(2) Investigative research on fine ceramics data base system:

In FY 1985, domestic and overseas data base systems on fine ceramics were examined, entrusted by MITI. Based on this survey, studies to examine the contents of the data, decide the thesaurus, and examine the design and operation of the system will also be conducted this year.

(3) Development of petroleum production members under high temperature, corrosive environment:

In this project which is forwarded by the Japan Petroleum Development Corp. and the Metallic Material R&D Center, high temperature, high-pressure corrosive gas increases as the oil well becomes deeper. Thus, inexpensive corrosion free pipes for petroleum production and sealing technology becomes necessary. Manufacturing technology of inexpensive pipes with ceramic coating, etc. are developed by this project for the above-mentioned objects. The Center is conducting R&D for this project, entrusted with part of the assessment tests.

(4) Survey on test assessment of fine ceramics:

Entrusted by the Basic Technology Research Promotion Center, the present test assessment system conducted for fine ceramics and prospective movements were investigated. An investigation committee was sent to the Western nations in March 1986 to study their test assessment methods for fine ceramics. Domestic and overseas fine ceramics related test assessments will be studied in more detail and prominent researchers in this field will be invited from abroad to conduct investigative studies mainly through the comparison of test assessment systems in Japan and overseas.

(5) Survey on new material related technology trends:

Entrusted by the Basic Technology Research Promotion Center through the Metallic Material Center, studies to clarify the degree of contentment of users on the present materials and their view on idealistic material properties as well as requested costs and market scale will be conducted.

(6) Survey on fine ceramics related international cooperation:

Entrusted by MITI, presently conducted research and technical developments by the advanced nations will be studied through international surveys and information exchanges. Programs of international cooperation will also be examined.

4.3 Smaller Business Promotion Activities

In addition to interdisciplinary and international cooperation extending over academic fields and industries which are said to be necessary for the advancement of fine ceramics, it is equally important to expand the fine ceramics industry base. As the age is shifting from mass production of a few goods to small lot production of goods, expectations of smaller businesses seem to have increased.

Thus, the Fine Ceramics Center promptly started the Smaller Businesses Promotion Committee in the summer of 1985 to discuss fine ceramics related promotion measures for smaller businesses starting with cooperative problems between national laboratories.

Publicity for the Fine Ceramics Center is also handled through regional gatherings, questionnaires, production, and distribution of bookets for smaller businesses, etc. Various opinions and demands are also taken into consideration in preparation for its opening in spring 1987.

5. Future Activities of JFCC

The JFCC will execute efforts for the accumulation of fine ceramics related technology through independent research activities and will also establish an assessment test system and standardization of fine ceramics. Plans and drafts for various projects related to fine ceramics will also be handled. The JFCC wishes to develop the fine ceramics industry in the application fields by becoming the major organ in coordinating R&D and supplying R&D sites for the above plans. Moreover, it intends to play the role of a mediator of the "seeds" of technology provided by universities and national research institutions and the "needs" of the industrial circles.

Meanwhile, a data bank will be constructed in order to bank all information regarding fine ceramics and provide a network with other material data banks. Thus, the technical "seeds" and "needs" of fine ceramics as well as information on various statistics and related industries will be available.

As the main organ engaged in fine ceramics related international cooperation, international joint research and surveys will be conducted by accepting overseas researchers and having researchers exchange views and information. International symposiums, etc. are also scheduled.

Education and diffusion activities for fine ceramics will also be forwarded through publications of organs, lectures, training sessions, and a fine ceramics fair.

6. Conclusion

Since 1985, the JFCC has begun R&D and surveying, as already mentioned, along with preparations for its construction, facilities, and R&D system. These activities will be successively expanded towards full operation from April 1987.

The JFCC intends to execute its greatest efforts in order to meet the expectations of the industrial circles on fine ceramics. We ask for your support to our activities.

Activities of New Diamond Forum

Tokyo CERAMIC JAPAN in Japanese Nov 86 pp 1027-1030

[Article by Junichi Sato]

[Text] 1. Introduction of New Diamonds

It is well known that diamonds have been and still remain mans' highest ranking ornament since the ancient Egyptian age with its noble radiance.

Meanwhile, diamonds have also been known to be extremely hard. As it is noted in the Bible that diamonds were used to process building stone, its history as a processing tool is as long as its use as an ornament.

Thus, diamonds have been used as tools for processing other diamonds, various precious stones, materials which are extremely difficult to grind, and high-precision works. However, as natural diamonds have been used in either case, its application range has been limited to special uses due to restrictions in resources.

The origin of diamonds has been conventionally researched as a theme which interests geophysicists. Meanwhile, it is also well known that specialists in supervoltage technology have been manufacturing artificial diamonds in order to be freed from resource restrictions.

Diamonds became widely applicable as an industrial material owing to the successful synthesis of diamonds by the hydrostatic pressure process in 1955 by General Electric (GE) of the United States. Since then, the application of diamonds, mainly diamond grindstones has sharply increased. The present sale of diamond tools amounts to over ¥70 billion a year with a 15-20 percent annual growth.

Moreover, the manufacturing of large diamond particles by the hydrostatic pressure process and membraneous diamonds by the gas phase process became possible. Thus, its application not only as a grinding tool and wear resistance tool which makes use of its hardness, but also as a widely functional material which uses the chemical, thermal, optical, and electronic properties of diamonds have also become available. Consequently, the name "new diamond" was chosen to redefine diamonds as functional material rather than just emphasizing their static property "hardness."

2. Details and Intentions of New Diamond Forum

2.1 Diamond Technology Research Society

The New Diamond Technology Research Society was started spontaneously in January 1982 by volunteers at a study meeting for researchers and technicians on wideranging fields from synthesis to application of diamonds. Members from 5 or 6 universities,national research institutions, and over 30 companies have regularly gathered to study and at times make field trips. Eleven meetings have been held up to June 1985 by gathering every 2-3 months. In November 1982, a seminar called, "The Dream of Mankind: Diamonds--Synthesis and Application Technology" was held in the Tokyo Institute of Technology's General Research Hall with over 100 participants. In February 1985, another seminar named, "Development of Diamonds as a New Material" was held in the Agriculture and Forestry Annuity Hall which also was a great success with over 200 participants.

2.2 Establishment and Purport of New Diamond Forum

An organizer of the said open seminar proposed "the necessity to reorganize the Diamond Technology Research Society and widely appeal to various circles for participation, in order to further advanced diamond research, application, and help the progress of related industries in our nation." This was promptly approved by the attendants.

With the cooperation of Yoshihiro Adachi, head of the Fine Ceramics Office of MITI at the time, the New Diamond Forum was established. The purport set for the forum was "promotion of information exchange between researchers and technicians of businesses, universities, and the government, which will contribute to the technical development related to production of diamonds with superior capacities and exploitation of new application fields and pursuit of industrial application possibilities through mutual studies and policy proposals, etc." An inaugural general meeting was held on 26 July 1985 at the Koyu Hall of Tokai University in the Kasumigaseki Building in Tokyo. Over 170 participants consisting of 108 from 75 firms, 30 from the Science and Technology Agency of MITI, 13 from 10 universities, 15 from the press, publishing world, and other guests attended the meeting. The appointment of the chairman of the forum was readily consented to by Shinroku Saito who is a great authority on diamond research in our nation and has sent out numerous researchers from his students. He also holds positions as the president of Nagaoka Technology and Science University and the chairman of the Ceramic Industry Association. The major activities of the New Diamond Forum are as follows:

(1) Study meeting: Conducted three to four times a year only by members. A theme is decided for each meeting mainly consisting of lectures by a few lecturers. Field trips are also conducted as much as possible.

(2) Symposium: Held for both members and nonmembers. The first symposium is scheduled to be held on 25-26 November 1986 at the Machinery Promotion Hall of Minato-ku, Tokyo.

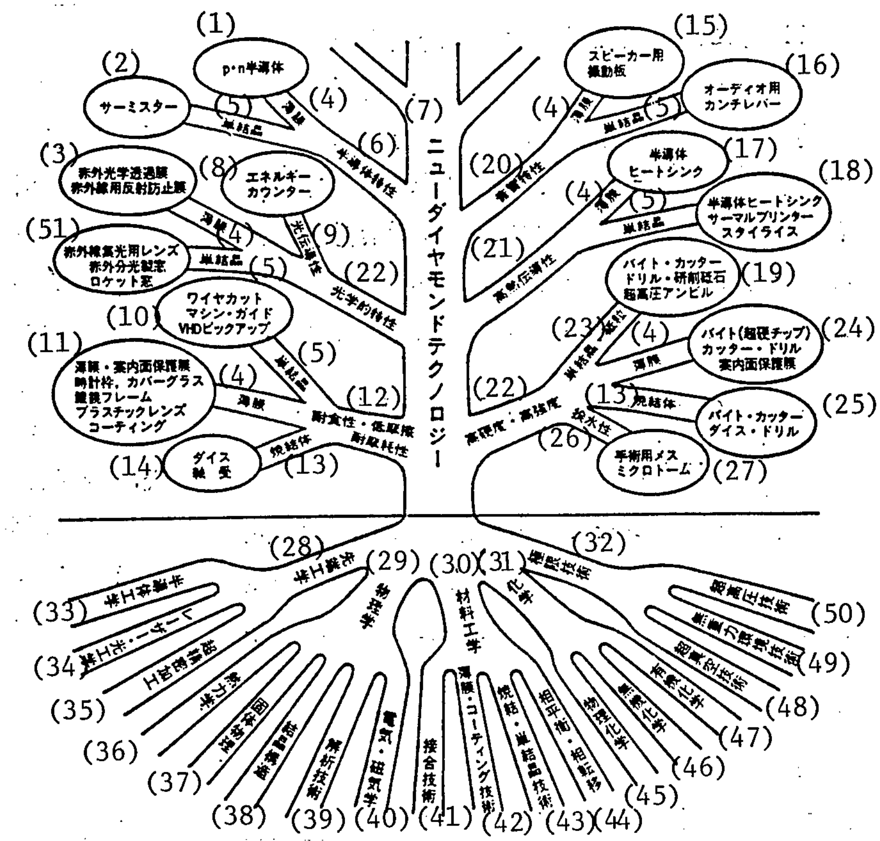

Figure 1. Foundation and Progress of New Diamond Technology (from "Status Quo and Measures of Fine Ceramics Industry" by Fine Ceramics Office of MITI, April 1986)

Key:

1. p/n semiconductors
2. Thermistor
3. Infrared optical transparent film, lens coating for infared rays
4. Thin film
5. Single crystal
6. Semiconductor properties
7. New diamond technology
8. Energy counter
9. Optical conductivity
10. Wire cut, machine guide, VHD pickup
11. Thin film/protective film of guide surface, clock frame, cover glass, plastic lens coating
12. Corrosion resistance, low abrasion, abrasion resistance properties
13. Sintered body
14. Die bearing
15. Loudspeaker diaphragm
16. Audio clank lever
17. Semiconductor heat sink
18. Semiconductor heat sink, thermal printer,
19. Cutting tool, cutter, drill, grinding stone, extra-high voltage anvil
20. Acoustic properties
21. High-temperature conductivity
22. High hardness, high strength
23. Single crystal, grindstone particles
24. Byte (carbide chip), cutter, drill, guide surface protective film
25. Byte, cutter, die, drill
26. Repellency
27. Surgical knife, microtome
28. High-tech engineering
29. Physics
30. Material engineering
31. Chemistry
32. Ultimate technology
33. Semiconductor engineering
34. Laser, optical engineering
35. Super-precision processing
36. Thermodynamics
37. Solid-state physics
38. Crystal structure
39. Analytic technology
40. Electromagnetism
41. Junction technology

[Continued]

[Continuation of key to Figure 1]

42. Thin film, coating technology
43. Sintering, single crystal technology
44. Phase balance, phase transition
45. Physical chemistry
46. Inorganic chemistry
47. Organic chemistry
48. Super-vacuum technology
49. Agravic environment technology
50. Extra-high voltage technology
51. Infrared condenser, infrared spectral window rocket window

(3) Open seminar: Held for both members and nonmembers, once a year, under a specific theme.

(4) Publication of an organ: Published three times a year for the time being.

(5) Survey, research, and entrusted research concerning new diamonds

(6) Related activities such as proposals to governmental agencies.

Other activities which are taken into consideration are lectures, discussion meetings, and editing and publishing books and materials.

3. Report on Major Activities

Approximately 1 year has passed since the establishment of the New Diamond Forum, at the writing of this report. The major activities conducted so far are reviewed in order to present an outline of its activities.

(1) Organ: The first issue of the NEW DIAMOND was published on 15 November 1985 followed by the second issue on 25 March 1986. Main points taken into consideration were, not to be too technical but at the same time not to be influenced by "easygoing" technical magazines because advanced technical information must be supplied to its members. Wideranging information from governmental policies, prospective markets, related patents to activities of related academic societies will also be supplied.

(2) Study meeting: Four regular study meetings have been held up to the present. With over 100 participants attending either meeting, increased interests and expectations on diamonds as a functional material have been reconfirmed. The overall theme and lecture theme of each meeting follow:

--First meeting, "Diamond Synthesis in Inorganic Material Properties Research Center, 10 September 1985, at Inorganic Material Properties Research Center,
"Diamond Synthesis by Gas Phase Process" by Matsukazu Kamo (Inorganic Material Properties Research Center)
"Diamond Synthesis by Static High-Pressure Process" by Nobuo Yamaoka (ditto)
"Diamond Synthesis by Dynamic High-Pressure Process" by Nobuo Setaka (ditto)

--Second meeting, "Role of Diamond in Advanced Processing Technology,"
28 November 1985, at Tsukuba Research Center of the Agency of Industrial Science and Technology

"Superprecision Cutting by Diamonds" by Yoshitaka Tatsue (Machinery Technology Research Center)
"Ceramics Research Processing by Diamond Grindstone" by Keisaku Okano (ditto)
"Discharge Grinding by Crustaceous Materials" by Ichiro Inazaki (Keio University)

--Third meeting, Special Lecture Meeting, 29 March 1986, at General Meeting of FY 1986

"Importance of Material Development in High-Tech Industries" by Tsuneo Nakahara (vice president of Sumitomo Electric Industries, Ltd.)
"Governmental Technical Development Promotion Measures" by Shogo Sakakura (Councillor of Agency of Industrial Science and Technology)

--Fourth meeting, "Impact Extra-High Voltage Technology and Diamonds," 4 July 1986, Tokyo Institute of Technology (Nagatsuda), General Research Hall
"Impact Compression Process and Application in Material Development" by Sho Sawaoka (Tokyo Institute of Technology)
"Impact Synthesis Technology and BN Tools" Masatada Araki (Nippon Oil & Fats Co., Ltd.)
"Diamonds in Meteorites" by Hiroshi Mori (Tokyo University)
"Diamonds and Impact Transition Mechanism of BN" by Nobuo Setaka (Inorganic Material Property Research Center)
"Dupont Diamond Grindstone Particles and Its Application" by Noboru Nishikawa (Dupont Japan)
"Carbon Conditions Under Impact Compression" by Kenichi Kondo (Tokyo Institute of Technology)

(3) Surveying: "Development and Application Trends of New Diamonds"

Among surveys related to the "Development and Application Trends of Bio-ceramics, etc." which were entrusted to the Fine Ceramics Association by the Japan Machinery Industry, the New Diamond Forum took charge of surveys for the above-mentioned theme. Specialists on diamond synthesis, properties, and application development were chosen among the members of the forum and asked to make a report on the subject. Questionnaires obtained mainly from these specialists became the base of a report on prospects of future application trends.

4. Future Activities

The activity plan of FY 1986 can be summarized as follows:

(1) Study meetings and seminars

Fifth Regular Study Meeting (September 1986) "Tohoku University and Diamonds"
First Diamond Symposium (25-26 November at Machinery Promotion Hall)
Second Open Seminar (January-February 1987).

(2) Organ NEW DIAMOND, Volumes 3, 4, and 5.

(3) Surveys: Surveys will also be conducted this fiscal year to pursue the possibilities of new diamond application.

An international symposium on new diamonds is also planned and will be held in 2 years. Participation is invited to diamond related specialists from abroad including Western nations. As this is the first attempt to conduct an international version of the New Diamond Forum, persons concerned are placing their greatest efforts in this project.

5. Conclusion

Thus, the establishment of the New Diamond Forum and its present and prospective activities have been introduced. Diamonds must naturally be considered in the sphere of ceramics and as new diamonds are spotlighted as new functional materials, active cooperatives are required with related academic societies and research institutes such as the Ceramic Industry Association. These organs are playing important roles in the research of new functions and applications of ceramics properties including fine ceramics and superfine ceramics. We expect to expand our activities under their guidance and ask for increased support for the ceramic industry.

A diagram related to the progress of new diamond applications drawn up by a secretary of the New Diamond Forum is included for reference (see Figure 1).

Activities of New Glass Forum

Tokyo CERAMIC JAPAN in Japanese Nov 86 pp 1030-1034

[Article by Yoshiro Suzuki]

[Text] 1. Preface

Glass has been used by mankind for 4,000 years. In its long history and development into industrial products for modern times, it has been a basic material supporting our daily living as flat glass, glass containers, glass bulbs, glass fibers, etc.

Thus, glass has matured in its application to various fields. However, it has further expanded its application sphere to high-technology in fields such as information processing, energy, and biotechnology. There is a new material called "new glass" which greatly differs from conventional glass in manufacturing process, composition, and function. This new glass which is still a pioneering material is expected to expand industrial opportunities used in optical communications, optical integrated circuits, optical memory and bioorganisms, and towards the 21st century construct a new industry.

2. Establishment of New Glass Forum

After close examination of the development course of new glass by the Japan Glass Products Industry Association for several years, the New Glass Forum was established in July 1985 under the guidance of the Ceramics and

Construction Materials Division of the Consumer Goods Industries Bureau in MITI with a target to accelerate the development of new glass with the co-operation of businesses, universities, and the government. Its present members, approximately 90 firms are composed of 55 percent glass producers with the remainder electric, chemical, and ceramics producers. Six optical fiber related firms including the Nippon Telegraph and Telephone Public Corp. have also joined the forum. Foreign enterprises such as Corning, Shot, and Pilkinton are also member companies.

Its organization is shown in Figure 1 and a general meeting is held once a year. The businesses of the forum are undertaken by the organizers' group which consists of six members from businesses, universities, and the government. The representative organizer is President Tetsuo Suzuki of Hoya Corp.

- General meeting
  - Organizers' meeting
    - Public Relations Committee
    - Executive Office
  - Planning Promotion Conference — Chairman Sumio Sakuhana
    - First Committee (light)
    - Second Committee (electricity, magnetism)
    - Third Committee (heat, machinery)
    - Fourth Committee (chemistry, biology)
    - Fifth Committee (material designing)

(Executives)

Representative organizer	Tetsuo Suzuki, president of HOYA Corp.
Organizers	Eizo Kanai, technological adviser of Asahi Glass Co., Ltd.
	Kei Shima, managing director of Nippon Sheet Glass Co., Ltd.
	Junichi Nagasaki, chairman, Nippon Electric Glass Co., Ltd.
	Sumio Sakuhana, professor, Chemical Research Institute of Kyoto University
	Ryozo Hayamizu, head, Government Industrial Research Institute, Osaka, Agency of Industrial Science and Technology

Figure 1. Organization Chart of New Glass Forum

3. Object of the Forum

The object of the forum is to advance the technical and industrial position of new glass by gathering researchers and technicians from businesses, universities, and governmental organs engaged in this field to exchange information and summarize their opinions in order to pursue the possibilities of new glass and make necessary proposals. The sphere of its activities is shown in Table 1.

Table 1. Activities of New Glass Forum

o Survey research for promotion of new glass	o Exchange of researchers and technicians from business, universities, and the government
o Entrusted surveys	o Seminars, study meetings, etc. related to new glass
o Proposals of new glass promotion measures	o Publication of organs
o International interchange, survey on overseas trends	o Educational, diffusion activities

Organizations such as the Flat Glass Association of Japan, Japan Glass Products Association, Electric Glass Association, Glass Fiber Association, Japan Glass Bottle Association, and Japan Optical Glass Association which retain traces of controlled economics have been groups restricted to men of the same trade with little contact between the organs. The New Glass Forum which consists of members from all glass related fields as well as enterprises of fields other than glass has united makers and users of the industry. This can be said as a movement to cover boundary fields and realize advancement in this age of diversification.

Other than members of enterprises, there are special members in the New Glass Forum who are prominent men from universities and governmental organs. They are asked for guidance on various problems and for participation in discussions.

4. Activities

The general operation of the forum is undertaken by the Planning Promotion Meeting composed of persons from businesses, universities, and the government engaged in R&D. The chairman of the meeting is Professor Sumio Sakuhana of the Chemical Institute of Kyoto University. Surveys of specific subjects, seminar planning and arrangement of suggestions are conducted by this organ. Survey research is forwarded by five technically specialized committees (Figure 1). Seminars are held approximately five times a year under an up-to-date theme in order to direct the course of the new glass industry and deepen mutual understanding of the field. The major themes discussed in the seminars are listed in Table 2. These seminars are open to universities and governmental organs but are closed to businesses. Each of the previous seminars have been well attended.

Table 2. New Glass Forum's Seminars

First seminar	Commemorative lecture meeting upon establishment of the New Glass Forum (September 1985)
Second seminar	Optoelectronics (November 1985)
Third seminar	Display (January 1986)
Fourth seminar	Semiconductors and glass industry (March 1986)
Fifth seminar	Mechanical high-performance new glass (May 1986)
Sixth seminar	Biological, chemical new glass (July 1986)
Seventh seminar	Manufacturing process of new glass (October 1986)

The NEW GLASS is published as an organ containing records of seminars, domestic and overseas news, etc. and distributed to the members.

Its office is located on the third floor of the Japan Glass Industry Center in Shimbashi, Tokyo and operated by fulltime workers.

5. What Is New Glass?

Let us consider the significance of new glass in this present day. In any age, new materials appear to meet the needs of the age, as a technological breakthrough and development in new technology applications. New glass is a glass which fully displays its capacities by making use of the multiple properties of glass. Its materials sphere is extremely wide, including amorphous glass and crystallized glass. The multiple properties of glass include the following seven features:

(1) Transparency and optical properties.

(2) Capable of changing composition consecutively. Thus, minute adjustment of physical properties is possible.

(3) Most chemical elements can be absorbed into glass as a solid medium.

(4) Capable of molding freely, from fibrous glass to flat glass and other differently formed items.

(5) Relatively high hardness and strength and is basically chemically stable.

(6) Capable of secondary processing such as crystallization, phase splitting, ion exchange, etc.

(7) Capable of endowing various properties by chemical composition.

The traditional process of applying these properties has created new types of glass by introducing new components into glass composition and melting it under high temperatures. However, a new glass cannot be acquired, simply by

Table 3. Representative New Glass (1985)

Functional fields	Functions	Glass/ crystallized glass	Basic composition	Applications
Optics	Photoconductivity	Optical fiber	SiO_2	Optical communications Microoptics
	Laser oscillation	Glass laser	Orthophosphoric acid, phosphorophyl	Nuclear fusion
	Photosensitivity	Photochromic glass	Na_2O-Al_2O_3-B_2O_3-SiO_2 (Ag, Cl, Br)	Permeability variable glass
	Optical memory	Amorphous oxide	Te-O	Photo disk
	Form stability	Photomask glass	SiO_2, silicate	Photo mask
Electro-magnetism	Ionic conductivity	High ionic conduction glass	AgI-Ag_2O-P_2O_5	Batteries
	Sonic conductivity	Delay line glass	R_2O-PbO-SiO_2 (R:alkali)	Delay lines
Heat	Thermal stability	Low expansion glass	TiO_2-SiO_2	Mirror part of astro-nomical telescope
		Low expansion crystal-lized glass	Li_2O-Al_2O_3-SiO_2 (ZrO_2-TiO_2)	Regenerator
Machinery	Alkali-resistance	Alkali resistance glass	Na_2O-ZrO_2-SiO_2	Reinforcement of cement
	High Young's modulus	Oxynitrate glass	Mg-Al-Si-O-N	Reinforcement of plastics
	Processing	Mica crystallized glass	K_2O-MgO-Al_2O_3-SiO_2-F	Electric insulation materials
	High strength	Complex crystallized glass	SiC-beta	High temperature mechani-cal construction materials
Chemistry	Isotropic carrier	Porous glass	SiO_2	Fixed oxygen, catalysts
	Solution set	Borosilicate glass	Borosilicate acid	Radioactive effluent set
Biology	Biological compatibility	Apatite crystallized glass	K_2O-Na_2O-MgO-Ca - P_2O_5-SiO_2	Artificial bones, artificial teeth

adding a new element, due to the advancement of research techniques, today. Instead, there are two major means to develop new glass. One of them is the origination of glass material and the other is regeneration by post-processing material.

While there are some glass compositions with prospective properties today, conventional melting processes cannot produce glass, due to melting under extremely high temperatures, instability in the air, inability to mix heavy metals, excessive water and oxygen, components in formulated materials with high vapor pressure at melting temperatures, easy crystallization, etc. In order to obtain such glass: 1) ambient melting; 2) superquenching; 3) gas phase process (CVD, vapor deposition spatter); and 4) liquid phase process (sol-gel process) are applied. Thus, marked expansion of the range of vitrification and the creation of glass material with new properties are becoming possible. As glass, bulk or film (includes amorphous) is available.

The second process is a means to denature the obtained material by heat processing (crystallization, phase splitting), reach-out, ion exchange, surface processing, radioactive processing, etc. The future of new glass lies in its demands as well as a breakthrough in new processing.

Representative new glass is listed in Table 3. While the table contains new glass although still not available for practical usage, the listed items are either presently widely used or highly prospective.

As future developments, ultra low loss optical fibers, optical integrated circuits, and memory elements are spotlighted.

6. Future Trends

Considering the future activities of the forum, this industry must be developed as a new industry, as new glass is still diverse and individualistic. As its estimated market scale is calculated to be ¥1.5 trillion by 2000, R&D promotion measures to realize this estimation must be proposed. Consequently, joining the forces of researchers from businesses, universities, and the government is required.

Furthermore, searching for R&D courses for new glass by joining its technological "needs" and "seeds" as the basis of advancing new glass, conducting diffusion and educational activities to increase the public's understanding of new glass, constructing a data base regarding its properties, making it available, and completing market research, statistics, and standards for new glass are required. While these tasks have already been started, it is necessary to accumulate efforts over a long term.

The New Glass Forum is an organization composed of members from enterprises and aims at the acquisition of business opportunities. Meanwhile, the Ceramic Industry Association is an academic organization. Both organs are pursuing R&D and the advancement of new glass, but interdependent to some degree. We wish to contribute to the activation of the new glass industry by cooperation of both organizations.

Statistical Chart on Fine Ceramics Production, Shipment, and Inventory
(Figures of July 1986 by Textile and General Merchandise Statistical Survey Office of MITI)
(Unit: ¥1 million, 1,000 items)

Items	Production		Shipment								Inventory
			Total	Sales						Others	
				Total sales		Exports		Domestic sales			
	Quantity	Ratio against previous month (%)		Quantity	Sum	Quantity	Sum	Quantity	Sum		Quantity
Total	5344656	99.1	5268029	5260451	34,613	647055	8,752	4613396	25,861	7,578	4581823
Total functional material	4501231	103.7	4488189	4485217	28,255	620144	6,775	3865073	21,480	2,972	2736129
Total IC package	186597	100.9	173878	173878	8,520	113791	4,859	60087	3,661	—	84632
Cerdip	161846	101.5	148160	148160	3,345	104339	1,844	43821	1,501	—	68301
Mutilayer	24751	96.6	25718	25718	5,175	9452	3,015	16266	2,160	—	16331
Substrate	226222	114.1	222269	222269	2,162	54280	328	167989	1,833	—	111411
Capacitor device	3843678	103.6	3835998	3835940	10,187	433913	643	3402027	9,543	58	2455556
Piezoelectric device	143157	95.8	155933	153111	4,548	12611	507	140500	4,041	2,822	60170
Gas sensor device	1160	99.1	1199	1131	876	250	346	881	530	68	298
Others	100417	104.1	98912	98888	1,964	5299	93	93589	1,871	24	24062
Total structural materials	843425	80.1	779840	775234	6,358	26911	1,977	748323	4,381	4,606	1845694
Catalytic carrier	36740	149.1	36598	36528	1,470	518	736	36010	734	70	994
Heat resistance material	47049	111.3	46958	46956	1,533	22305	582	24651	951	2	8784
Tool material	668261	76.4	600733	596201	1,300	950	333	595251	967	4,532	1808303
Corrosion-resistant, abrasion resistant material	80225	82.7	81146	81146	1,818	1751	310	79395	1,508	—	15002
Others	11150	75.0	14405	14403	236	1387	16	13016	221	2	12611

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CSO: 4306/7509

MITSUI GROUP FIGHTS FOR INS LEADERSHIP

Tokyo ZAIKAI TEMBO in Japanese 1 Feb 87 pp 82-91

[Article by Shiro Kamisono]

[Excerpts] In the earlier days of high growth, when there were no such words as "computer communication society" or "information network system," the old leaders of the Mitsui Group had their so-called "Mitsui Heavy Industries Project." When this project failed, in spite of all their efforts, one of them said, "We must admit that Mitsui is not as strong in hardware as the heavy industries. However, when the day comes in which knowledge and information can be sold like merchandise, that will be the time for Mitsui."

Now that the "day" has come, it is no wonder that the Mitsui Group is doing everything it can to be the leader in the "New Media society." The Mitsui Group was actually one of the first of Japan's six corporate groups to come to grips with New Media. In May 1982, the Mitsui Group reorganized the Mitsui Office Automation Conference into the Mitsui Information System Conference (MISCO). MISCO included the 24 firms which are members of Niki-kai, which is a gathering of the presidents of Mitsui Group firms. The comprehensive fundamental research developed by MISCO covered all major New Media fields, such as banking, VAN, videotex, communication satellites, CATV, protocol conversion, and improvements in software development efficiency.

As MISCO was also open to firms not belonging to the Mitsui Group, it attracted non-Mitsui members like Sony Corp. and Ito-Yokado Co., Ltd., together with Kanebo, Ltd., Matsushita Electric Works, Ltd., etc. With more than 50 participants, MISCO has become the largest group of its kind among the six major corporate groups.

MISCO is also involved with experiments in the practical use of New Media. In spring 1984, four of its members which deal directly with consumers--Mitsui Bank, Ltd., Mitsui Real Estate Development Co., Ltd., Mitsukoshi, Ltd., and Ito-Yokado Co., Ltd.--started experiments in the commercialization of storefront information services using videotex (a two-way character and pattern information system).

These experiments gained an excellent reputation for the variety of information that could be presented on store products and special events, on condominiums, houses, other properties, financial information, and other publicity.

There were many inquiries from other members of MISCO for assistance in developing home banking or home shopping services in the future.

When the Ministry of Posts and Telecommunications started experiments with the CAPTAIN (character and pattern telephone access information network) system, all the main firms making up the Mitsui Group, including Mitsui Bank, Ltd., Mitsui and Co., Ltd., Mitsui Real Estate Development Co., Ltd., Mitsui Construction Co., Ltd., Mitsui Mutual Life Insurance Co., Ltd., Taisho Marine and Fire Insurance Co., Ltd., Toshiba Corp., etc., participated by providing a wide range of information in order to enhance the image of the Mitsui Group.

It is said that the bond that ties the companies of the Mitsui Group together are relatively weaker than those in other corporate groups that derived from prewar zaibatsu plutocracies. One reason is the vertical structure of the prewar Mitsui group, which was changed drastically when the war was over, according to the analysis of the "godfather of Mitsui," Goro Koyama, an adviser to Mitsui Bank, Ltd. Another reason is the fact that the main bank of the prewar Mitsui Group, the Imperial Bank, had to be split into Mitsui Bank, Ltd., and Dai-Ichi Bank, Ltd., after the war.

In 1950 the major leaders of firms which used to belong to the prewar Mitsui Group formed the "Getsuyo-kai [Monday meeting]" to cultivate friendship among directors in order to organize a new Mitsui Group. In 1961, "Niki-kai" was finally formed by the presidents of major Mitsui Group firms, just like the "Kin-yo-kai [Friday meeting]" of the Mitsubishi Group and "Hakusai-kai" of the Sumitomo Group. "Niki-kai" now has 24 member firms including Toshiba Corp., Oji Paper Co., Ltd., Mitsukoshi, Ltd., and Onoda Cement Co., Ltd., with Toyota Motor Corp. participating as an observer.

However, the members of "Niki-kai" were still far from being firmly united. For example, the Kanebo Corp. did not join "Getsuyo-kai" although it used to be one of the major prewar Mitsui firms, and the Toshiba Corp., which joined it recently, is behaving independently.

To enhance solidarity among Mitsui Group firms, Mitsui Interbusiness Research Laboratory was established in 1978. This organization includes 25 firms centered around the members of "Niki-kai," whose purpose is to "develop cooperation between firms with different businesses and to create new business categories that a single firm would find difficult to create."

The first concrete result of these efforts is seen in the 10 types of high-tech houses with HA (home automation) features, developed by the 13 firms which are members of the Housing Industry Special Committee. The achievement of this project was of great help in establishing and promoting technical exchanges between house builders and construction material makers in the Mitsui Group. This has also resulted in a recent increase in transactions between Mitsui Group companies related to the housing industry.

The purpose of MISCO is an extension of Mitsui's interbusiness project. The target of MISCO, the information communication business, is a strategic field that is expected to grow a great deal in the future, and almost all Mitsui

Group firms have already attempted to develop business in this field. MISCO is a means of channeling their individual energies into the Mitsui Group. By presenting a project that can be achieved by concentrating the forces of companies working in different fields, MISCO tries to realize another purpose--enhancing solidarity within the Mitsui Group.

MISCO started its activity of studying various New Media by gathering engineers from the member firms. In June 1984, when experiments with the INS [Information Network System] were going to start in Mitaka, Tokyo, MISCO reorganized its structure to establish a new INS Policy Committee with several subcommittees. The committee consists mainly of sales engineers, and its target is to pursue business sales rather than develop cooperative research.

To catch up with the recent trends in communications using personal computers, 35 firms of the Mitsui Group also established the Personal Computer Communication Experiment and Research Committee. The committee has experimented with electronic conferencing using the electronic bulletin board services provided by NTT PC Communications. Also, in spring 1987, the committee started the shared use of high-speed digital communication lines for communications inside the Mitsui Group.

This service is the result of examinations conducted by MISCO to find the ideal shared-network utilization as a way of reducing communication costs, and is based on the resale of the digital communication line that Mitsui Bank Software Services rented from NTT Corp. Since the cost per communication is lower when the communication lines have a greater utilization rate, shared use has reduced the data and voice transmission costs by 30 percent compared to the ordinary NTT tariff. Mitsui Bank Software Services is also planning to offer VAN and calculation services in addition to line resale services, and the final target is the construction of a large-scale VAN which will include non-Mitsui firms.

The cooperation of the Mitsui Group in MISCO is not only for solidarity and the activation of the group. Another target is the handling of data communications, a leading industry in the future, under the leadership of the Mitsui Group. This enterprise is led by Mitsui and Co., Ltd.

Together with Mitsubishi Corp., Mitsui and Co., Ltd., is one of the few general trading companies which are participating in all Class I electrical communication enterprises, which form the infrastructure of the age of New Media. The enterprises in which Mitsui and Co., Ltd., is participating include DDI called "second NTT" (7.5-percent investment), Nippon Telecom (10-percent investment with two directors), Nippon Kosoku Tsushin (17-percent investment with two directors), and Tokyo Tsushin Network.

In the field of satellite communications, too, Mitsui and Co., Ltd., has established Nippon Tsushin Eisei in collaboration with C. Itoh and Co., Ltd., and is in keen competition with Uchuu Tsushin, which is part of the Mitsubishi Group. In fall 1985, Mitsui and Co., Ltd., also participated in the establishment of the Nippon Satellite Network Project, a network service research and planning company which provides data transmission and leased-line services using transponders leased from Nippon Tsushin Eisei.

Mitsui and Co., Ltd., has also taken a lead in fundamental New Media fields such as videotex. It imported the Canadian videotex system called TELIDON and has provided various information services through terminals placed in Mitsukoshi department stores. The business has been further advanced by Tokyo Teleguide, a videotex company established in February 1985 under co-operation between several Mitsui financial firms and other non-Mitsui firms such as Dentsu, Inc., Sony Corp., and Nomura Securities Co., Ltd., TELIDON is a different type of videotex system from CAPTAIN, which is the Japanese version of the videotex marketed by NTT Corp., and Mitsui is giving severe competition to the CAPTAIN videotex center promoted by Mitsubishi Corp., SECOM Co., Ltd., Kyocera Corp., etc.

To expand the TELIDON business throughout Japan with franchise chain operations, Mitsui and Co., Ltd., established Sapporo Teleguide in Sapporo in 1987. Sapporo Teleguide is a major base of the TELIDON camp in Hokkaido, with cooperation from major firms in Hokkaido, such as Hokkaido Takushoku Bank, Ltd., Hokkaido Bank, Ltd., and Hokkaido Gas Co., Ltd., as well as from 28 firms participating in Tokyo Teleguide. By connecting the Teleguide services in Tokyo and Sapporo directly, the user of the service can now obtain the town guides or other information on the area.

Mitsui and Co., Ltd., has also invested capital in other videotex enterprises all over Japan, such as Kansai Videotex Kikaku and Media Hokuriku, as well as in projected firms in Fukuoka and Nagoya.

As TELIDON type videotex developed, many users have also been asking Mitsui and Co., Ltd., to sell the videotex terminals for the development of their own services. To meet these requirements, Mitsui and Co., Ltd., has developed a Mitsui-version videotex terminal based on the technology licensed from Canadian INFOMART and on Mitsui's original technology. This new advance in the field of videotex hardware seems to be working well. The company expects to sell 300 to 500 terminals for use in domestic OA and local town-guide services, and expects to export a similar number to North America.

Although it is a general trading company, Mitsui and Co., Ltd., is strong in such enterprises as developing, selling, and exporting equipment associated with New Media. It has also developed a personal computer, M1, which incorporates the new software "Works" developed by Microsoft Corp., and is shipping it as an OEM product to Zenith. This newtype of personal computer was originally developed by Microsoft and is based on an idea presented by engineers of Mitsui and Co., Ltd., based in New York. This fact supports the saying that "Mitsui is founded on a human basis, while Mitsubishi is founded on an organizational basis." Cooperation in the course of the development of the M1 has resulted in Kazuhiko Nishi, president, Japanese ASCII Corp. and vice president of Microsoft Corp., becoming Mitsui's strategic advisor for personal computer sales in the U.S. market.

When a project is too big for a general trading company, Mitsui and Co., Ltd., also advances in such fields by establishing subsidiaries. The first subsidiary of this kind was Nippon Univac Kaisha, Ltd., which was established in 1958 and has already grown to be one of the major listed firms. Another

example is ADAMNET, a company selling local area network systems, founded in collaboration with TELEDATA, which is a venture business in telecommunications equipment.

The local area network system marked already includes many firms but Mitsui and Co., Ltd., was the first general trading company to participate. ADAMNET initially sold digital PBS equipment manufactured by Canadian Northern Telecom, but it is also planning to combine different pieces of equipment from different manufacturers to offer a system that can best meet individual user requirements, which is not possible for other sales companies which often can sell only equipment manufactured by companies with which they have strong ties.

Mitsui and Co., Ltd., has also applied New Media to educational systems. In collaboration with (Jonan Gakuen) private school, Mitsui is developing CAI (computer-aided instruction) and educational programs using CATV, etc. When this system is completed in spring 1988, it will be used in 150 branches of (Jonan Gakuen), and the know-how will also be used in general training systems to be used in future businesses.

While the Sumitomo Group has NEC Corp. and the DKB (Dai-Ichi Kangyo Bank) Group has Fujitsu, Ltd., the Mitsui Group includes no such specialized company in data communications that can be the key company in promoting data communications strategy in the group. This is one reason why Mitsui and Co., Ltd., stands alone in the Mitsui Group.

There is one would-be key company in the Mitsui Group, and this is Toshiba Corp. But it has only a short history as a member of the Mitsui Group, having just joined "Niki-kai" in 1971, and there was also an incident in the fifties which spoiled the confidence of Mitsui and Co., Ltd., with respect to Toshiba Corp. This was the refusal of Toshiba Corp. to cooperate in introducing the "Univac" computer, manufactured by Sperry, in Japan. This is also why Nippon Univac Kaisha, Ltd., was established as a joint venture between Sperry and Yoshizawa Kaikeiki, not with Toshiba Corp.

Nippon Univac Kaisha, Ltd., also has a problem that prevents it from becoming the key company in the Mitsui Group; that is, it is a joint venture based on 34.2 percent investment from both Sperry and Mitsui and Co., Ltd. Now Sperry has merged with TOB of Burroughs, which wants to compete with IBM by enlarging its business. As Burroughs already owns a 100-percent subsidiary Nippon Burroughs in Japan, the relationship between Nippon Univac, now a joint subsidiary of Burroughs, and Nippon Burroughs is so delicate that Mitsui and Co., Ltd., cannot rely on Nippon Univac Kaisha, Ltd., as its sole key company.

Mitsui and Co., Ltd., then decided to promote cooperation between Toshiba Corp. and Nippon Univac Kaisha, Ltd., while Mitsui and Co., Ltd., remained as the organizer of this united key company project. It is expected that this loose cooperation will contribute to solidarity within the Mitsui Group in the long run, while its looseness will allow the participation of other non-Mitsui firms.

The cooperation between Toshiba Corp. and Nippon Univac Kaisha, Ltd., started with the OEM supply of a high-speed multimedia multiplexer from Toshiba to Nippon Univac. Multiplexers are key pieces of equipment in local area networks and VANs and are used to connect various devices at very low cost.

Nippon Univac Kaisha, Ltd., has been strong in general purpose computers, but not in small computers or communication equipment. The OEM supplier of multiplexers was changed from Mitsubishi Electric Corp. to Toshiba Corp. after a strong request from Mitsui and Co., Ltd. This relationship has advanced. Thus, Toshiba Corp. has recently started to supply communication equipment to Sperry itself. Even the participation of Toshiba capital in Nippon Univac Kaisha, Ltd., is being discussed.

Another example of close cooperation between Toshiba Corp. and the Mitsui Group firms is the HA system developed together with Mitsui Construction Co., Ltd. The HA system not only allows it to control home equipment or sensors externally via telephone lines, but also allows two-way communication by transmitting alarms detected by sensors installed in the house. The home bus lines including telephone wires and coaxial cables are installed at the time of construction so that the user can expand the HA system any time after he starts living in the house. It is estimated that the HA market will grow to ¥170 billion in 5 years, and these two firms are planning to cooperate more fully to increase their share of this market.

On the other hand, Nippon Univac Kaisha, Ltd., has advanced in the "smart" building business since the beginning of 1987. The company covers all stages required for leased buildings, from system design and installation to maintenance. It provides telephone, data, and pattern communication services using digital PBXs, business data-processing services for operation processing, management support, electronic filing, etc., using a general-purpose computer, and 24-hour security services.

However, Mitsui Real Estate Development Co., Ltd., has already advanced in the field of smart buildings, as seen in the Kasumigaseki Building and the centralized building control center in Mitsui Building No 2 in Nihonbashi, Tokyo. Although the advance of Nippon Univac Kaisha, Ltd., could mean the risk of double investment for one purpose by two members of the Mitsui Group, the group has as yet done nothing to allocate services between them.

Nippon Univac Kaisha, Ltd., has also started to get involved in videotex services. Its new software is run on a general-purpose host computer and is compatible with both CAPTAIN and TELIDON. To enhance its sales of videotex, Nippon Univac Kaisha, Ltd., has absorbed the sales department of its subsidiary Nippon Univac Information Systems.

At almost the same time, Toshiba Corp. is also marketing a new videotex center system based on CAPTAIN and NAPLPS [North American Presentation Level Protocol Syntax] to which TELIDON conforms. Including the teleguide services developed by Mitsui and Co., Ltd., three firms in the Mitsui Group are developing videotex in different ways.

When there is a conflict of interest, cooperation even inside the same group is not assured in the Mitsui Group, in which the firms are often more conscious of their independence than they are of solidarity. The Mitsui Group not only needs to make an effort to achieve solidarity among its members but also needs to be a powerful organ that can supervise and modify the behavior of its members. Recently, more than 30 ex-members of "Niki-kai" formed "Mitsui Kyuyu-kai [Old Friends of Mitsui]" in order to discuss the "selfishness" of the members of the Mitsui Group, but it is still not known if each of these ex-presidents can transcend the interest of the firm from which he came. Each of the firms making up the Mitsui Group has a long history of its own, and has excellent talent, technology, and management ability. Each has formed its own opinion with respect to New Media.

For example, Onoda Cement Co., Ltd., is a very progressive company and was the first Japanese business to introduce a computer, in 1956. It started sales of OA equipment in cooperation with Fujitsu, Ltd., in 1981, and established a new company, Ookusu, for the promotion of OA business in July 1984. After starting a LAN (local area network) system for the first time in the cement industry in November 1986, it now continues to supply know-how and facilities to Ookusu so that it can grow to be an integrated information company.

Mitsui Warehouse Co., Ltd., is also planning to advance into the VAN business by utilizing its new physical distribution information system. The company has been using one host computer, an ACOS System 800 manufactured by NEC Corp., in the main office building for centralized processing. The new system uses decentralized, distributed processing using 17 satellite computers which are TOSBAC DP Series units manufactured by Toshiba Corp. As this has reduced the load of the host computer, it is not assigned to connect with the host computers of clients. The new integrated physical distribution VAN is also planned to provide transportation services such as vehicle management and freight-tracing services.

Another Mitsui Group company, Mitsui Shipbuilding and Engineering Co., Ltd., is planning to advance into the VAN business. The first step is the systems engineering subsidiary named Mitsui Zosen System Giken established in spring 1986. This company was established by separating the systems business division of Mitsui Shipbuilding and Engineering Co., Ltd., and it develops businesses in four main fields: systems engineering, software, data processing, and CAD/CAM.

In addition, Sanki Engineering Co., Ltd., which is the largest Mitsui Group company in general construction equipment, is planning to participate in semiconductor manufacturing. Its first step is a 100-percent subsidiary named TMD (Tokyo Micro Devices), which will start its business with the production of optical devices such as semiconductor laser devices. The processing technology that TMD is expected to acquire will later be used by Sanki Engineering Co., Ltd., itself for the production of semiconductor devices.

Mitsui Construction Co., Ltd., has already successfully achieved the introduction of personal computer communications connecting workplaces with the

head office via telephone lines. Before the end of May 1988, the number of personal computers used in the main and branch offices and in workplaces will increase to 700 units, and these will connect these locations with an all-company on-line system. While the UNIVAC 1100-71 host computer in the main office is connected to nine branch offices via leased optical-fiber cables, personal computers are connected to them via public telephone lines. The on-line system allows information collected all over Japan to be input to the database in the host computer, for accessing from any personal computer.

Another project of Mitsui Construction Co., Ltd., is the sale of optical cable housing tubes made of fiber-reinforced concrete material, which was developed using the technology of Toray Industries, Inc. In the growing field of optical fibers, another firm in the Mitsui Group, Mitsui Toatsu Chemicals, Inc., is also planning to promote low-cost coating materials.

These examples are just a few of the attempts of some Mitsui Group firms. The potential of each Mitsui Group firm in the field of data communications is extensive and strong. The problem for the Mitsui Group does not lie there but, as indicated repeatedly, it is how to unify the potential of individual firms through cooperation and solidarity, as promoted by Mitsui Gyosai Kenkyuujo [Mitsui Interbusiness Research Laboratory], and by MISCO. We will examine a few such examples.

Mitsui and Co., Ltd., Mitsui Petrochemical Industries, Ltd., and Toshiba Corp. have developed a united enterprise for the production and sale of optical disks. Toshiba Corp. has developed the manufacturing technology, while Mitsui Petrochemical Industries manufactures 500,000 optical disks per year in its plant, and Mitsui and Co., Ltd., supports sales through the Optical Memory System established in 1985. It is also possible that Mitsui Toatsu Chemicals, Inc., will participate in this enterprise with its new disk-coating technology.

As FA (factory automation) may experience rapid growth in the future, Mitsui and Co., Ltd., has established a new partnership with TEC (Toyo Engineering Corp.) and Jamuco Nippon Keiei. This partnership recognizes the neutrality and independence of each participating firm and is regarded as a new form of cooperation which facilitates the participation of many firms that do not belong to the Mitsui Group.

Mitsui and Co., Ltd., and TEC have also established a technical partnership in the development of AI (artificial intelligence), the first step toward developing so-called fifth-generation computers. Based on the technology introduction agreement that Mitsui and Co., Ltd., concluded with Intelligent Terminal, Ltd., an AI venture business in England, Mitsui and Co., Ltd., and TEC have developed an expert system structuring tool in the Japanese language called EX-TRAN.

In fall 1986, Mitsui and Co., Ltd., also established Mitsui AI Kenkyuukai [Mitsui AI Study Group] with 11 members of the Mitsui Group, and EX-TRAN was the first fruit of the study session. At MISCO, too, ES Kenkyuukai

[Expert System Study Session] created a prototype using an expert system structuring tool, and will provide the results of the examination of the system using it to the members of the ES Kenkyuukai and Mitsui Gyosai Kenkyuujo. The Mitsui Group is tackling AI seriously.

Mitsui Bank, Ltd., another leader in the Mitsui Group, is cooperating with Toshiba Corp. on experiments in a banking system using smart cards and, with Mitsukoshi, Ltd., in home shopping services using the CAPTAIN system. Mitsui Bank, Ltd., is vigorously supporting Toshiba Corp. so that it will be recognized as the key company in the Group for its contributions such as the experiments in on-line banking systems using a telecommunications satellite and the development of a voice synthesizer for bank telephone services.

Mitsui Bank, Ltd., has also established an integrated think tank named Mitsui Ginko Sogo Kenkyuujo [Mitsui Bank Integrated Research Center]. The purpose of the research center is to reorganize software firms within the Mitsui Group, thus enhancing the software development of the group as a whole and preventing opportunities from being wasted by firms going outside the group. This is the first attempt of a corporate group to organize a software house.

Compared to other former zaibatsu corporate groups such as the Mitsubishi Group, the Mitsui Group seems to be rather depressed, perhaps because the Iranian petrochemical project is in danger and it has a relatively lower ranking amongst city banks of the Mitsui Bank, Ltd. However, this mood could be blown away if participationin data communications works well, because every firm in the group is intensely determined to collaborate with other firms to acquire leadership in this key industry in the future. With the highest total income among the six corporate groups in Japan, the Mitsui Group has a greater potential than many people estimate. If solidarity could be added to it, the Mitsui Group would be ready for a counterattack that could stamp out its rivals.

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